The Victorian Naturalist

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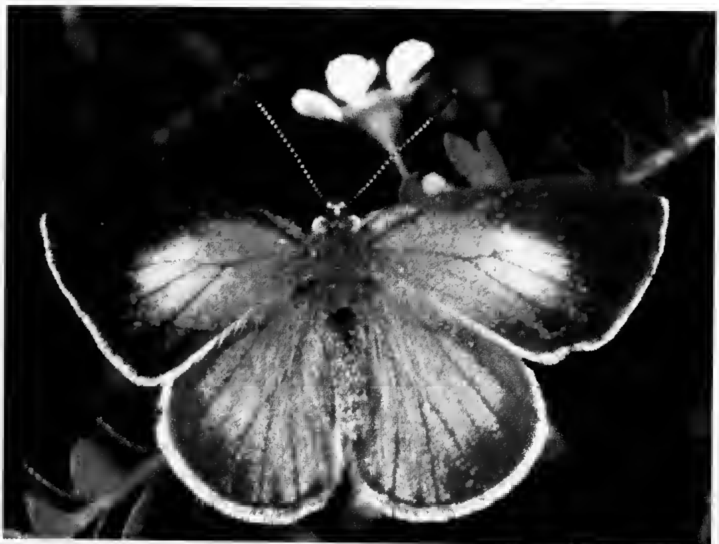
Invertebrate conservation special issue



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From the Editors

Invertebrate species are vastly more numerous and incredibly more diverse than animals with backbones. As to the first, they make up about 95% of all known animal species. Perhaps because of the second, invertebrate species, particularly the insects, are of enormous importance to the earth's ecosystems. Pulitzer Prize-winning biologist EO Wilson has observed that 'If insects were to vanish, the environment would collapse into chaos.' This sentiment was echoed by David Attenborough in his recent natural history series *Life in the Undergrowth.*

Despite their numbers and importance, however, invertebrates generally receive far less attention than other animals, from both the nature-loving public and conservationists. Butterflies are perhaps the best-studied group of invertebrates, but the extent of attention focused on them is not matched in the case of most others of their kind. It seems the average fly (May-, Damsel- or otherwise) or stick insect does not rate well against the larger—and more readily apparent—mammal, bird, or even snake or lizard.

This Special Issue of *The Victorian Naturalist* collates contemporary conservation data on this somewhat neglected but vitally important range of species. The Editors are pleased, as ever, to provide this opportunity to focus on invertebrate conservation. The issue addresses questions related to invertebrates and their conservation, as well as providing a good summary of current conservation strategies applied to particular species. While the preparation of 'special' issues such as this involves some production difficulties, these are greatly outweighed by the value contained between the covers.

Front cover: *Candalides absimilis* (female), a distinct form of this species found at Buchan and Mitchell River NP. Photo supplied by Ross Field.
Back cover: Gippsland Burrowing Crayfish. Photo by Greg Hollis, DSE Noojee.

Male (upper) and female (lower) Golden Sun-moth *Synemon plana*. Photographs supplied by Lucy Gibson. See article on p. 254.

Introduction: Invertebrate species conservation in Victoria

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This dedicated issue of *The Victorian Naturalist* is about invertebrates, that massive variety of animal life so important in sustaining ecosystems, yet disregarded by most people, to whom the need for their conservation and very existence is not apparent. Without invertebrate participation in processes such as pollination, decomposition and recycling, as predominant members of food webs, and as controllers of pests in crop and commodity protection, the world would differ greatly from that which we see and use, and human interests would be compromised severely. An earlier special issue of this journal (Yen and New 1995) gave a broad perspective of invertebrate conservation needs in Victoria, and this issue examines more recent progress with greater focus on individual species and their needs. Some of these species have been studied for many years, and summaries of their conservation programs are given; others are more novel and indicate the continuing need and expansion of interests in invertebrate conservation in the state.

Invertebrates were amongst the earliest nominated candidates for scheduling as threatened species under the *Flora and Fauna Guarantee Act* 1988 (FFG), and the ecologically diverse trio of the Giant Gippsland Earthworm, the Hemiphlebia Damselfly and the Eltham Copper Butterfly were an important collective flagship in demonstrating the great variety of invertebrate ecology to people to whom such animals were strangers, and to whom their conservation and wider evolutionary importance were novel (Yen *et al.* 1990). Since then, a considerable variety of insects, snails, freshwater crayfish and others have been added to the FFG schedules, so that (at 20 July 2006) 71 invertebrates are listed for attention in the state. This special issue presents short accounts of some of these species (mainly those which have inspired the pioneering and establishment of the discipline of invertebrate conservation in Victoria), to demonstrate recent increases in knowledge and management related to their conservation needs. The species listed so far are but a tiny fraction of possible deserving candidates. Some of the species discussed below are not yet listed for formal conservation significance, and exemplify the variety of possible future requirements. Unlike the major vertebrate groups, for which FFG schedules of threatened species are relatively complete, the listed invertebrates are simply those for which some case of need has been made and adjudged valid. Numerous vast groups of insects and others are not represented by listed species. This does not reflect lack of equivalent need but simply lack of capability to evaluate their conservation status, and lack of specialists versed in the biology of those creatures. The inevitable wider consequence is that invertebrate conservation has been progressed mainly by attention of members to a few 'well-known' groups, amongst which butterflies are paramount, and (more rarely) through the zeal of individual proponents for members of less familiar groups.

Elsewhere in the world, two other contrasting perspectives on how best to pursue invertebrate conservation occur. First, in parts of the northern temperate zone, predominantly in the United Kingdom and parts of western continental Europe, taxonomic, biological and distributional knowledge of many invertebrate groups is sufficient for finely honed species-focused conservation programs based on very detailed knowledge as a foundation for effective management and recovery (Stewart and New 2007). Programs on the British butterflies, for example, draw on well over a century of collector interest and detailed historical records of incidence and abun-

dance, which allow trends in distribution and abundance to be found and interpreted (see Asher *et al.* 2001).

Second, the vast diversity of invertebrates over much of the tropics renders any such equivalent focus on individual species very difficult, because of poor taxonomy (with most species undescribed), poor ecological understanding and, as importantly, the lack of resident expertise and potential support for conservation in relation to the needs of burgeoning human populations (Lewis and Basset 2007). Australia manifests an intermediate position: our butterflies, and some other insects, are indeed reasonably well-known through hobbyist interests, but most other invertebrate groups remain more intangible as the province of very limited interest by few people. Whereas the need for conservation of many a fly, snail or worm may be real, the transfer of 'a name on a list' to a practical and successful management program for such species is an enormous step, particularly when based on very limited knowledge. However, and as emphasised in a major overview of non-marine invertebrate conservation needs in Australia (Yen and Butcher 1997), the vast diversity of invertebrates ensures that only a tiny proportion of species can ever be considered individually. For most, the only practical avenue to their security is to protect the habitats they frequent.

We have deliberately limited this issue to representative terrestrial and freshwater invertebrates in Victoria, simply because many of these are better known than many of their marine counterparts, and not in any way to diminish the importance of marine invertebrates or the need to conserve them. Animals such as butterflies, dragonflies, and some moths and beetles, are far better known, so that their conservation needs and priorities can be assessed more realistically, on a scale of 'secure' to 'critically endangered' to reflect urgency of the attention needed. Allocating invertebrates convincingly to a particular category of threat is a complex task, but necessary as a means to give priority to the most needy species in a work climate in which support is inadequate for all needs to be met. Only for butterflies has a national Action Plan been formulated (Sands and New 2002) to appraise the needs and priorities for a whole invertebrate group in Australia. Similar exercises would be feasible for dragonflies and damselflies, and a few select groups of other invertebrates, but the conclusions by Butcher and Doeg (1995) that 'Current information on aquatic invertebrates in Victoria is insufficient for most approaches to conservation' and 'While a few species of conservation significance have been identified, concentration on the single-species approach will leave many others open to further decline' are equally true for most terrestrial taxa.

The act of listing a species under FFG, or equivalent legislation elsewhere, implies concern for its future usually because of evident decline in abundance or distribution, including loss from sites changed by human activities, and commonly accompanied by definition of the 'threats' causing such concerns. It is relevant to emphasise here that simple 'rarity' is not alone evidence for conservation need. Vast numbers of invertebrate species are indeed 'rare', in some combination of occurring in low numbers, or in very limited areas, and in being ecologically specialised. However, many such species are not 'threatened', and may continue to thrive unless conditions change. Many are known from only single sites, or very few such places, but may need only a hectare or less of suitable habitat in order to persist – small habitat areas that could not support an effective population of larger animals such as most vertebrates. Such sites may indeed merit monitoring to detect any threats that arise, but it is usually not feasible (other than by improved buffering of important habitat to prevent loss and degradation) to plan to protect them from chance events such as wildfire or flooding. The more focused basis for conservation concern is 'threat', not least because detection and definition of threat(s) dictates a path to constructive management through threat removal and ameliorative measures to conserve the population or species affected. Site (broadly, physical habitat) security is the foundation of this; without a 'place to live' a species or population is doomed. Simply safeguarding a site does not guarantee conservation, however, and continuing management is commonly needed to sustain the

resources and conditions needed by any particular species. This paragraph exemplifies the twin conservation paradigms distinguished by Caughley (1994), namely (1) the 'small population paradigm' for which conservation concerns arise simply from the population being small, and so subject to adverse genetic effects such as inbreeding and the possible effects of habitat limitation, so that the population could be extirpated by a single catastrophe, and (2) the 'declining population paradigm' for which the causes of decline (i.e. threats) define parameters for management.

Invertebrate conservation concerns in Victoria exemplify both these schools of thought. A number of species have been listed under FFG simply because they are rare, some of them narrow range endemics, but with little specific evidence of threat. The number of discrete populations is one of the criteria incorporated into the World Conservation Union's categories of threat. Other species are truly threatened, predominantly through loss of (or major changes to) their habitats and critical resources. The initial act of listing such poorly-understood species under FFG ideally leads to accumulation of knowledge that, in turn, reveals either (1) that management for greater ecological understanding, threat amelioration and recovery is needed, and definition of the specific components of a convincing management plan, or (2) that the initial concerns were misplaced and that the species is more abundant, widespread and/or secure than earlier supposed. The latter, as well as successful management leading to demonstrated recovery, may be grounds for delisting the species, not least to refocus support for more deserving taxa on the list. Two other grounds for delisting a taxon, both rare but noted here for completeness, are (1) if the species is known to have become extinct, for example through monitoring of the last or only known population, and (2) if taxonomic changes reveal it not to be a distinctive entity, but synonymous with a non-threatened taxon. However, isolated or other 'significant' populations may still be eligible for conservation attention.

In this issue of *The Victorian Naturalist*, authors have been invited to review and comment on the status of and progress to understanding conservation needs for a variety of Victoria's threatened (or presumed threatened) invertebrates. A further paper exemplifies how a Victorian institution is supporting wider invertebrate conservation within Australia through a captive breeding programme of the Lord Howe Island Stick Insect – the only non-Victorian species included, but one to whose well-being State expertise is contributing significantly. These cases include some species that have attracted attention over the last 20 years. Collectively these accounts demonstrate changing attitudes to invertebrates in Australia, and the ways in which objective scientific evidence is playing important roles in formulating conservation protocols. The consequences of FFG listing, noted by Clunie and Reed (1995) include (1) protection from take, an action with very mixed benefits for conservation (Greenslade 1999); (2) construction of an Action Statement, to elaborate on what is known and what needs to be known to ensure long-term survival in the wild ; (3) moves to protect habitat and critical resources from further despoliation and loss; (4) becoming foci for funding, commonly with additional support by formation of community groups; (5) elevated public profile through a variety of advisory and media exposure; and (6) obligations to consider the species in planning decisions for land or water management. In these steps, some of the invertebrates listed for conservation protection under FFG have become some of the best-known non-pest invertebrates in the State. For others, no such plan is currently possible. The above 'consequences' are all evident in the examples we summarise here. Collectively they help to advance wider knowledge of the conservation needs of these intriguing animals.

Many uncertainties and challenges remain. The over-arching effects of future climate change have as yet been scarcely defined, for example, but may markedly influence the vulnerability of many invertebrate species (including a variety of alpine region endemics) that already survive in only small areas of marginally suitable habitat that may be changed dramatically within a few decades.

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Female Golden Sun-moth *Synemon plana*. Photograph supplied by Lucy Gibson.

The Trafalgar millipede *Lissodesmus johnsi* Mesibov, 2006 (Diplopoda: Polydesmida: Dalodesmidae)

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Abstract

Lissodesmus johnsi, L. dignomontis and *L. tarrabulga* are endemic to the Strzelecki Ranges in Gippsland, Victoria, where the three species may once have formed a distribution mosaic. *Lissodesmus johnsi* now appears to be restricted to c. 60 ha over three sites in the western Strzelecki hills, which were almost entirely cleared of their forest cover in the late 19th and early 20th centuries. (*The Victorian Naturalist* **124** (4), 2007, 197-203)

Introduction

Some time in August 1890, the 70-year-old William Kershaw – Victorian entomologist and field naturalist – collected several species of millipedes 'near Trafalgar' in Gippsland. He preserved the specimens in alcohol and deposited them in the National Museum of Victoria.

Seventy-odd years later, the specimens were carefully examined by the visiting New Zealand specialist Peter Johns. Although Johns was reasonably certain that one of the Trafalgar millipedes was in the same genus as a species earlier described from Melbourne, he decided not to name it as a new species. Instead, he described and illustrated it as '*Pseudoprionopeltis (Australopeltis)* sp.' (Johns 1964)

Another 40 years passed, and *Australopeltis* had meanwhile been

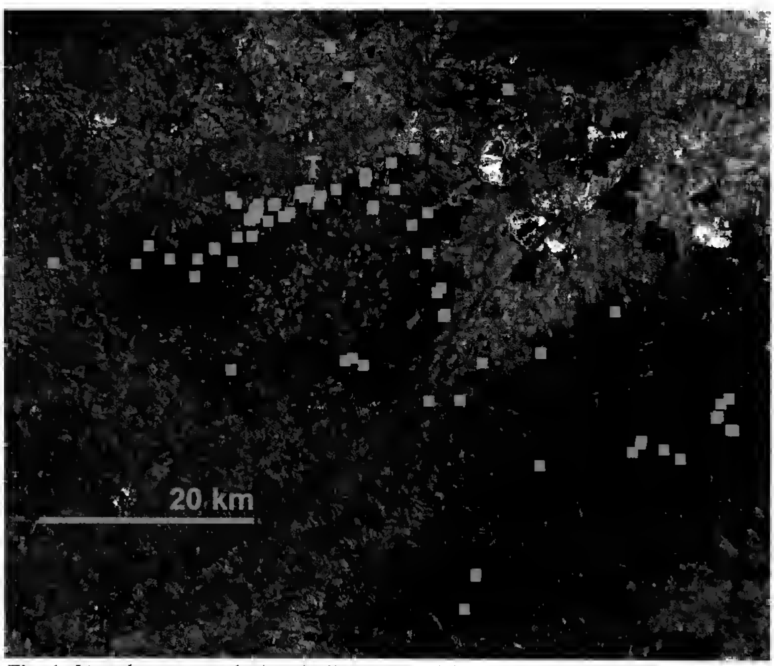

Fig. 1. *Lissodesmus* search sites (yellow squares) in west and south Gippsland. Background is natural-colour Landsat image from 2000. Dark green patches are forest plantations and native forest; remainder is farmland and urban and industrial clearings. T = Trafalgar.

replaced by the older name *Lissodesmus* (Jeekel 1983). I was examining specimens for a revision of *Lissodesmus* when I came across the Kershaw material in Museum Victoria in Melbourne. The Trafalgar species was most unusual, evidently a *Lissodesmus* but apparently a highly derived one. I needed a few more specimens for a proper description. Was the millipede still living, I wondered, 'near Trafalgar'?

The short answer was 'yes' and I obtained my specimens, later naming the species *Lissodesmus johnsi* (Mesibov 2006). However, the taxonomic and conservation issues arising from this study were more complicated than I anticipated. The Trafalgar millipede is one of three remarkable species confined to Gippsland's Strzelecki Ranges. It is also, I suspect, closer to extinction than any other Victorian millipede.

Millipede hunting

Between September 2004 and July 2006 I spent 26 field days searching for *Lissodesmus* at 86 sites in west and south Gippsland (Fig. 1).

Unlike the familiar Portugese millipede and many native millipedes, *Lissodesmus* species require constant high humidity. They live in wet rotting wood and moist humus-rich soil. In Victorian wet forest where lyrebirds are absent, *Lissodesmus* species can be found in deep leaf litter on the forest floor. Where lyrebirds regularly disturb this microhabitat by raking, *Lissodesmus* are very hard to find outside of logs.

Victoria has 11 known *Lissodesmus* species, i.e. the 10 described or redescribed in Mesibov (2006) and a new species discovered in the Grampians in 2005. Most are pink or reddish in colour and up to 20 mm long as adults. Like most of the 18 known Tasmanian *Lissodesmus* species, the Victorian species typically have fairly small ranges, but *L. martini* is widespread and abundant from Melbourne's eastern suburbs to Dargo.

I found *L. martini* as far south as Yinnar in the Morwell River valley, but in the Strzelecki Ranges it is replaced by a closely related species, *L. gippslandicus*. The two

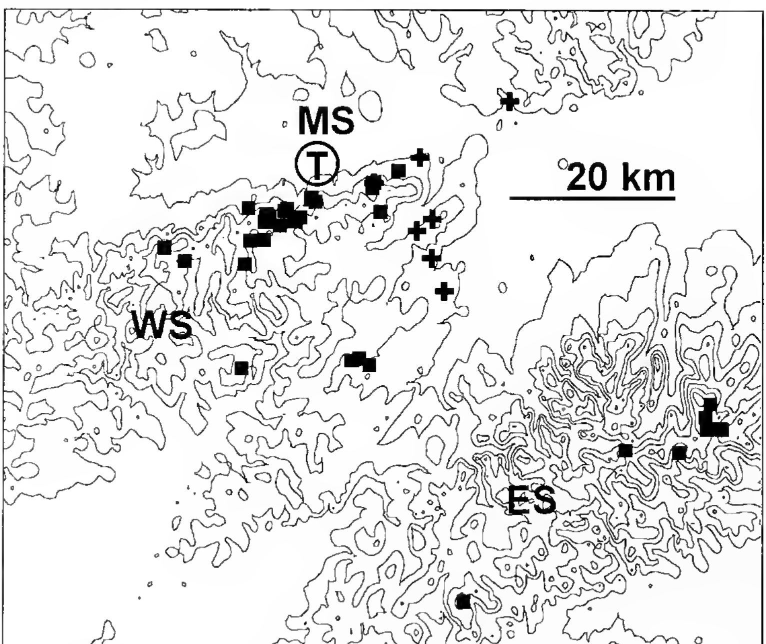

Fig. 2. Localities for *Lissodesmus gippslandicus* (squares) and *L. martini* (crosses) in west and south Gippsland. Map extent is the same as in Fig. 1. Contours are at 100 m intervals. WS = western hills of Strzelecki Ranges, ES = eastern hills of Strzelecki Ranges, MS = Moe Swamp, T = Trafalgar.

distributions meet but overlap only slightly (Fig. 2). This spatial arrangement, known as *parapatry*, is common in millipedes, and many genera, such as *Lissodesmus*, form species mosaics in the landscape (Mesibov 2003).

The *johnsi* group

Three closely related *Lissodesmus* species are remarkably different from other Victorian and Tasmanian *Lissodesmus*. The three are here called the *johnsi* group, and comprise *L. dignomontis*, *L. johnsi* and *L. tarrabulga* (Mesibov 2006). Adults in this group are small, pale and oddly juvenile in some anatomical details (Fig. 3).

The *johnsi* group are also set apart geographically, occurring only in the Strzelecki Ranges, where their distributions may once have formed a mosaic (Fig. 4). The boundaries between mosaic tiles can be remarkably narrow in millipedes, with overlap zones less than 100 m wide. I was fortunate to find a sharp boundary of this kind between *L. dignomontis* and *L. johnsi* in a bush remnant at Yarragon South, just southwest of Trafalgar.

To a greater degree than in most other Victorian millipedes, the *johnsi* group are microhabitat-specific. They appear to be much less tolerant of dry conditions than the co-occurring *L. gippslandicus* (Fig. 3), and have not yet been found in forest where rotting logs are absent, or where repeated hot burning has greatly reduced organic matter in the topsoil.

Local history

Twenty years before William Kershaw's visit, the western Strzelecki hills were covered in tall, wet eucalypt forest, with a dense understorey of smaller trees, shrubs and treeferns, or of tall sedges (Adams 1978; TJ Coverdale in Shire of Korumburra 1966). Travellers through this hill forest often noted the presence of huge eucalypt logs lying on the ground (Adams 1978).[1] The Moe Swamp, north of the hills, was at least partly covered in tea-tree species, with scattered eucalypts (Adams 1978). Between the Swamp proper and the hills were broad wooded flats.[2] A very large area 'near Trafalgar' was good *L. johnsi* habitat in 1870.

A few years later the first settlers arrived. The subsequent clearing of the forested hills of south Gippsland has been documented in extraordinary detail in a collection of first-hand reminiscences, *The Land of the Lyre Bird* (Shire of Korumburra 1966). First, the forest understorey and the younger eucalypts were felled, an operation called 'scrub cutting'. On a suitable day the following summer, the felled material was burned, and 'picking up' began, i.e. the collection and burning of 'everything in the shape of timber except the standing stumps' (WHC Holmes in Shire of Korumburra 1966).

Clearing and burning were very thorough.[3,4] Clearing often began along creeklines and proceeded upslope, and creek gullies, which might have served as litter fauna refuges during natural wildfires, were used as kilns to burn logs (WHC Holmes in Shire of Korumburra 1966; G. Matheson in Shire of Korumburra 1966).

In the exceptionally hot and dry summer of 1898, west and south Gippsland were swept by intense bushfires. Many of the large eucalypts which had been ringbarked and left standing on the developing farmlands were burned down. Although lives, livestock, buildings, fences and sown pastures were lost in the fire, 'it had done some good in clearing up a lot of old logs and undergrowth, and in burning down and burning away thousands of big trees' (TJ Coverdale in Shire of Korumburra 1966).[5]

Settlers took advantage of the 1898 fires to do further 'picking up'.[6] Rabbits arrived in the district at about the same time (Adams 1978), and rabbit control included burning the stumps and logs used by rabbits for shelter. Earlier in the 1890s, work began on clearing and draining the Moe Swamp, and settlement on the formerly wet flats proceeded quickly.[7]

For a social and economic history of the settlement of the northern portion of the *johnsi* group range, see Adams (1978). The key point is that much of the formerly forested area had been cleared, burned and converted to mainly treeless, logless farmland within 30 years of settlement.[8] By the 1920s, some of that land had become 'densely covered with bracken fern and blackberry bramble' (report quoted in Adams 1978), but very little was allowed

Fig. 3. Adult females of *Lissodesmus gippslandicus* (top) and *L. johnsi* (bottom).

to regenerate to native forest in the following decades. Instead, steep or derelict farmland was planted with *Pinus radiata* and, more recently, *Eucalyptus globulus*. Although some other native millipedes have successfully colonised the older plantations, I have not yet found any of the *johnsi* group in plantation litter.

Lissodesmus johnsi today

Over the past 50 years, as evidenced by aerial photographs, native forest cover has increased in the farmed landscape of the western Strzelecki hills. Much of this increase has been in and adjoining deep gullies from which stock are now largely excluded. I have carefully searched a number of these 'new' wet forest patches near Trafalgar without finding *L. johnsi*. The most likely explanation is that the species became locally extinct when its log and topsoil shelters were burned away in the late 19th and early 20th centuries. Dispersal of *L. johnsi* to these 'new' patches is blocked by wide barriers of pasture.

I have so far located only three populations of *L. johnsi*, all 'near Trafalgar' (Fig. 5). A small population occurs on a few hectares of privately owned wet forest near an old sawmill site at Yarragon South, on a steep south-facing slope above a farm dam. A second small population occupies a portion of an 8 ha patch of privately owned riparian forest, also at Yarragon South; *L. johnsi* occurs here in parapatry with *L. dignomontis*.

The largest known population is in Uralla Nature Reserve (UNR) in Trafalgar. The 45 ha Reserve is owned by Trust for Nature and managed by a committee of volunteers under the auspices of Baw Baw Shire. A detailed history of the property is not yet available, but it is known to have been used by charcoal burners and may thus have been an informal timber reserve. Within UNR, *L. johnsi* is found in rotting logs both in shady wet forest close to flowlines and in open forest on ridgelines.

The UNR forest is contiguous with privately owned forest to the south and east and with Shire forest on the Trafalgar tip site to the west. I have searched these surrounds for *L. johnsi* without success, although *L. gipplandicus* and other native millipedes are present. The surrounding forest appears to have far fewer rotting logs than UNR, and may be largely 'new' forest in the sense noted above, i.e. forest regenerated on formerly cleared land. UNR and the other two known *L. johnsi* sites, although burned in the past, were apparently never completely cleared for agriculture.

Conservation recommendations

The UNR forest is probably large enough to support the existing population of *L. johnsi* indefinitely. The eucalypt over-

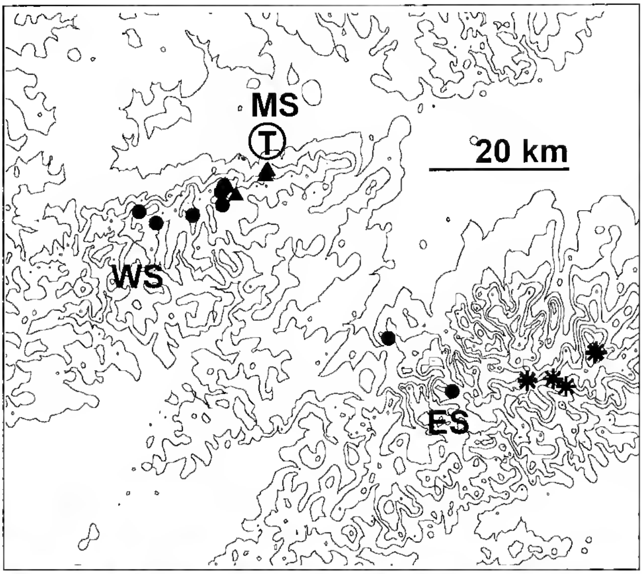

Fig. 4. Localities for *Lissodesmus dignomontis* (circles), *L. johnsi* (triangles) and *L. tarrabulga* (stars) in west and south Gippsland. Map extent is the same as in Fig. 1. Contours are at 100 m intervals. WS = western hills of Strzelecki Ranges, ES = eastern hills of Strzelecki Ranges, MS = Moe Swamp, T = Trafalgar.

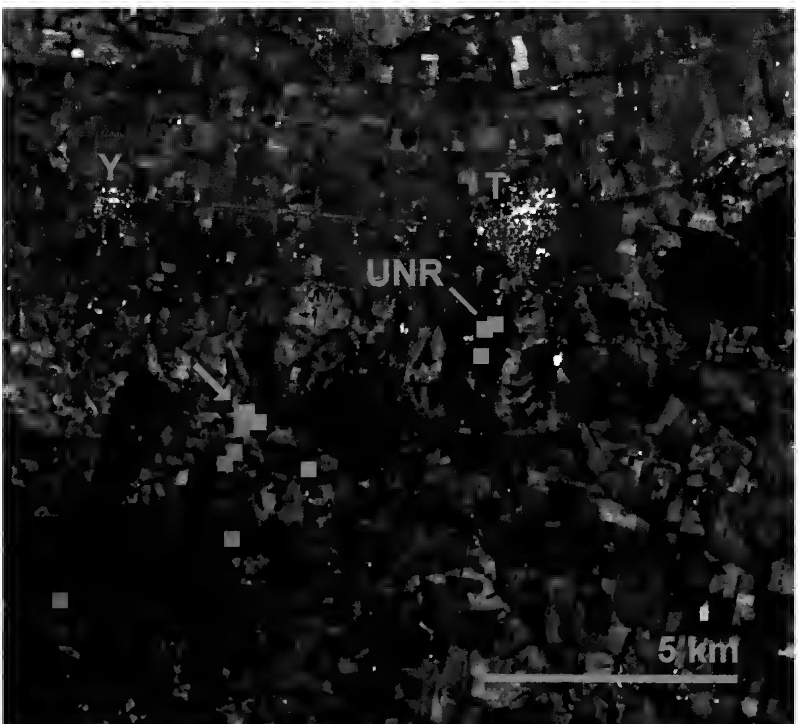

Fig. 5. Localities for *Lissodesmus dignomontis* (red squares) and *L. johnsi* (yellow squares) near Trafalgar (T). Background is natural-colour Landsat image from 2000. Dark patches are forest plantations and native forest, remainder is farmland and urban clearings. Uralla Nature Reserve (UNR) occupies the north-central portion of its forest patch. *Lissodesmus dignomontis* and *L. johnsi* occur in parapatry in the forest remnant marked with an arrow, south of Yarragon (Y).

storey is uneven-aged, and natural treefalls and gap- or fire-promoted regeneration should provide an ongoing source of rotting logs for *L. johnsi* microhabitat. Clearing trees and removing firewood from any part of UNR would reduce this critically important rotting wood resource.

The rotting wood resource is also at risk from an intense ground fire. The best protection against such a fire is periodic fuel reduction burning of standing shrubs, grasses and sedges, carried out under conditions when ground-surface litter and logs are moist enough not to burn.

I am reluctant to recommend translocation of *L. johnsi* to small forest patches elsewhere in the western Stzrelecki hills. It is not yet clear how mosaic parapatry is maintained in millipedes (Mesibov 2003), and it is possible that translocation will either fail because of the presence of the sister species *L. dignomontis*, or will succeed to the detriment of the latter.

Conclusion

It is a lucky historical accident that the Trafalgar millipede *Lissodesmus johnsi* is still extant, c. 115 years after its discovery. Virtually the whole of what is likely to have been its former range, north, south and east of Trafalgar, was cleared for agriculture and is now pasture, cropland or forest plantation. While its sister species *L. dignomontis* and *L. tarrabulga* are likely to persist in large blocks of native forest elsewhere in the *johnsi* group mosaic, *L. johnsi* will avoid extinction only if the core of its remaining range, Uralla Nature Reserve, is managed so as to maintain a well-dispersed stock of rotting logs within standing native forest.

Acknowledgements

I am very grateful to the many landowners in west Gippsland who gave me access to their properties, and especially to Geoff and Jackie Tims, Ken and Wendy Savage, and John Poppins of Yarragon South for their support, hospitality and local knowledge. Historical information was sourced with the assistance of Jean Huffer of the Trafalgar and District Historical Society, and of staff at the State Library of Victoria and the Royal Historical Society of Victoria. A number of GIS layers and a 20 m DEM for my study area were kindly provided by the Department of Sustainability and Environment, Victoria. The Landsat image in Fig. 1 is from an image layer in the National Carbon Accounting Toolbox and Data Viewer, Australian Greenhouse Office. The contours in Figs. 2 and 4 were generated from the 9 second digital elevation model of Australia, version 2.1, Geoscience Australia. I thank an anonymous referee for helpful comments on a draft of this paper. The *L. johnsi* study was funded by the author.

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Notes

[1] 'After a few days we started off one morning to visit our selection, about two miles further on. We followed a survey line (now Sanders's lane), running in the direction we wished to go. Through the dense forest we pushed our way – we walked along logs, climbed over logs, crept under logs, crawled through logs, but seldom or never did our feet touch the ground.' (W. Johnstone in Shire of Korumburra 1966, p. 213)

[2] 'The Northern Gippsland railway line, after passing through Warragul, runs into a stretch of rich grey soil flats, the timber being mostly white gum, with occasional specimens of blackwood. Settlement in this district, which has railway centres at Darnum, Yarragon and Trafalgar, on what is known as 'the flats' is of comparatively recent date.' (*Trafalgar and Yarragon Times*, 19 August 1902, p. 1)

[3] 'It was perhaps a grave error to destroy all this valuable timber... Yet most of us deemed it inadvisable to leave even one acre of standing

timber.' (M. Hansen in Shire of Korumburra 1966, p. 218)

[4] 'Total clearing of the land was made easier when 'stoving' was found to be an effective way of getting rid of tree stumps. This method was to remove the earth from the base, build a stack of wood around and set fire to it. The resulting heap of glowing coals was completely covered with tightly packed earth, and kept covered. This produced a hot, slow burning fire which incinerated a great part of the standing trunks and gradually crept along underground destroying most of the giant root system. This would take months, and the selector, carrying a lantern in his hand, would go around them at night when he was able to see if any needed covering with more earth.' (Back to Yarragon Committee 1978, p. 10)

[5] 'The only benefit the [1898] fires did was to sweep many paddocks clean of timber that would otherwise have taken years to clear.' (F.P. Elms in Shire of Korumburra 1966, p. 341)

[6] 'Deprived of the more profitable timber industry [following the 1898 bushfires], settlers were perforce compelled to give more attention to agriculture. To this end the task of clearing the land of blackened butts and trunks, by bringing together the charred timber and remains in heaps around the bases of dead trees, and lighting covered fires until everything was burned, was vigorously pursued.' (Daley 1960, p. 137)

[7] 'Trafalgar is beautifully situated almost at the foot of the Strzelecki Ranges, and a fine view can be obtained from the summit of one of them, for as the tourist looks out from his exalted position over the great expanse of country spread out before him, and sees the numerous square cultivation paddocks, green as a leek, and the numbers of brightly-painted homesteads dotted about in all directions, he can scarcely realise its former wildness, when it was a vast morass, covered with rough grass and impenetrable scrub, presenting a striking contrast to the aspect of the place to-day...' (Smith 1905 , p. 574)

[8] 'What a pleasing contrast was presented between the first original homestead of the veteran pioneer (surrounded by forest, inhabited by dingoes, lyre birds, wallaby's, [sic] and other wild animals and birds, with no means of ingress and egress save a narrow pack track winding over gullies and wooded ranges...) and the smiling homestead of the prosperous farmer or dairy-man of to-day. Greenfields, studded with contented dairy cattle, is to-day the prevailing order of things, with comfortable cow-sheds and dairy houses fitted with up-to-date modern appliances, all trending to show the marked progress and wonderful developements [sic] which has [sic] taken place under the steadfast and persistent efforts of the old and new pioneer, a complete transformation from non-productive country to a prosperous community.' (Report of a lantern-slide lecture by pioneer settler Frank Geach in the Mechanics Institute, Trafalgar; *Trafalgar and Yarragon Times*, 11 November 1902, p. 4)

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One hundred Years Ago

THE MOSQUITO

… When a mosquito bites, it places the end of the lower lip on the victim's hand, and shakes its head, thus sawing through the skin. The lower lip now bends up near the head, and so the end of it is raised, while the six piercers sink into the flesh. The muscular throat now acts as a pump, and the blood is speedily pumped up.

In return for our kindness in giving the mosquito blood, she gives us with the saliva two things we decidedly object to. First there is poison, which produces a most irritating effect on some people, while others seem to be immune to it. Secondly, there are very tiny microscopic animals, which give rise to the deadly diseases already mentioned. The mosquito is the involuntary, but necessary, agent in the transmission of these animals; but why she has poison, which apparently serves no useful purpose, is a puzzle.

From *The Victorian Naturalist* **XXIII**, p 216, March 1907

Habitat preferences of the Otway Black Snail *Victaphanta compacta* (Cox and Hedley, 1912) (Rhytididae)

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Abstract

A survey in August-October 2004 determined the distribution of the Otway Black Snail *Victaphanta compacta* at three locations in the Otway Ranges. *V. compacta* was found in Temperate Rainforest (gullies), Wet Forests (ridges) and the ecotone between these two (slope) and was found predominantly around the base of trees and in leaf litter, and fewer were found associated with logs and or the tree trunks. (*The Victorian Naturalist* **124** (4) 2007, 204-209)

Introduction

The Otway Black Snail *Victaphanta compacta* Cox and Hedley, 1912 is a land snail endemic to the Otway Ranges, Victoria. *V. compacta* belongs to the family Rhytididae, carnivorous land snails found in southern Africa, the western islands of the Pacific, New Guinea, New Zealand and Australia (Smith 1971, 1977, 1998; Smith and Kershaw 1979; Meads *et al.* 1984).

The four species in the genus *Victaphanta* are characterised by thin, light shells primarily made of conchin (a protein matrix) with very little calcareous material (Smith and Kershaw 1979). The shapes of their shells range from spherical to subspherical and the shell colouring ranges from black, dark brown, through to light yellow (Smith and Kershaw 1979). The body is predominantly black, with three of the species exhibiting orange colouration on the foot (*Victaphanta milligani* Pfeiffer, 1853), mantle frill (*Victaphanta atramentaria* Shuttleworth, 1853, *V. milligani* and *Victaphanta lampra* Reeve, 1854) or in the mucus (*V. atramentaria* and *V. lampra*) (Smith and Kershaw, 1979). *Victaphanta* is restricted to south-eastern Australia occurring within the Wet Forests and Cool Temperate Rainforests of Victoria and Tasmania; all four species are found in leaf litter (Smith and Kershaw 1979).

Victaphanta compacta is aptly named the Otway Black Snail (Figs. 1 and 2) as its shell colour is predominantly a glossy

Fig. 1. Otway Black Snail *Victaphanta compacta*.

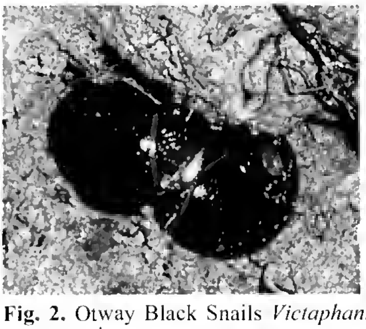

Fig. 2. Otway Black Snails *Victaphanta compacta*, mating.

black in the outer whorls with a small patch of yellow/white on the inner whorl (Smith and Kershaw 1972, 1979). The shell colour can vary between individuals ranging from yellow to dark brown (Smith 1970) as well as black. The diameter of the shell ranges from 20 to 28 mm (Gabriel 1930; Smith 1970; Smith and Kershaw 1979). The colour of the body of the snail is also black (Smith 1970; Smith and Kershaw 1979).

Victaphanta compacta is easily diagnosed by its lack of orange pigmentation anywhere on the body or in the mucus (Smith 1970) and distinguished from its closest relative *Victaphanta atramentaria* by a smoother and more spherical shell (Gabriel 1930; Smith 1970).

Little is known on the biology of *V. compacta* except that the snail is carnivorous (Smith 1971) and lays white eggs with a diameter of 2-3 mm (Smith 1970). It is not known how long these snails live. No information on the behaviour of *Victaphanta compacta* is available.

Victaphanta compacta is endemic to the Otway Ranges of southern Victoria (Smith 1977; Smith and Kershaw 1979) and is found in Wet Forests and Cool Temperate Rainforests (Smith 1977). Cool Temperate Rainforests have a patchy distribution within the Otway Ranges, being restricted to deep, sheltered gullies with moist conditions and at the headwaters of creeks and rivers throughout the region (VEAC 2003). Wet Forests occur on mountain sides with high rainfall and in wet valleys (Conn 1993). Wet Forests are also found emerging from the Cool Temperate Rainforests, called Mixed Forests as they contain a mix of Wet Forests and Cool Temperate Rainforests flora (Ashton and Attiwill 1994). Cool Temperate Rainforest has an overstorey of Myrtle Beech *Nothofagus cunninghami* and Blackwood *Acacia melanoxylon*, while the Wet Forests are dominated by Mountain Ash *Eucalyptus regnans*, Mountain Grey Gum *E. cypellocarpa* and Messmate *E. obliqua*. Both vegetation types have tree-ferns.

The IUCN Species Commission Mollusc Specialist Group listed *Victaphanta compacta* with the IUCN as *Endangered* in 1996. It was given a Red listed category of E A2c, due to a potential for the species to experience a 50% reduction in population within the next ten years because of habitat loss (World Conservation Union 2003). It is listed as *Threatened* under the Victorian *Flora and Fauna Guarantee Act* 1988 (SAC 2001) because of possible population decline due to loss of habitat caused by Myrtle Wilt destroying the canopy layer, and human activities, and because the species is endemic with a limited distribution and low abundance.

Part of the requirement of a listing under the *Flora and Fauna Guarantee Act 1988* is the preparation of an Action Statement that includes background information and species description, the distribution, habitat and life history of the species, and recommendations for conservation (Butcher *et al.* 1994). Before any actions can be recommended for the conservation of *V. compacta*, information is required on its distribution, abundance, age structure of populations, and reproductive rates and success. This survey is part of a study that investigated some of the information that is lacking for *Victaphanta compacta* (Burrell 2004). It assessed the habitat and shelter site preferences of *V. compacta* by determining whether:

1. It is found in Wet Forest (ridge), Cool Temperate Rainforest (gully), or the Mixed Forest (the ecotone on the slope between the ridge and gully) habitats.
2. It has a preferred shelter site between habitat types and overall shelter site preferences. The shelter types are defined as base (of trees and tree ferns), leaf litter, logs or vertical (trunk). This will determine whether *V. compacta* shelters in specific areas within its habitat or if the species is a generalist in microhabitat choice.

Study Area

The Otway Ranges are located on the south coast of Victoria and are approximately 2110 km^2 in area (Conn 1993). Elevations range from 670 metres at Mt Cowley (VEAC 2003) down to sea level along the coast. The geology of the area is primarily of non-marine sandstones and shales, and the soils consist of fertile loams, which support extensive forests (Conn 1993). The average rainfall for the area is between 1750 mm and 2000 mm

with the highest rainfall period from May to September. Temperatures vary from the mid-summer maximum of 20-27°C to the mid-winter minimum of 3-4°C. The Ranges can also receive light snowfall at the higher elevations during winter (VEAC 2003).

The area investigated in this study includes from west of Lavers Hill, up to Beech Forest, Forrest, across to east of Lorne, to Apollo Bay and along the coast back to Lavers Hill

Methods

One of the most common forms of survey method used to investigate mollusc diversity, habitat preferences, abundance, distribution and biology is the quadrat survey method. It is thought that measured searches such as quadrat surveys provide the most accurate snail counts when compared to casual searches (Mesibov 1998; Stringer and Montefiore 2000). In the present study, quadrat surveys were used as habitat preferences were being investigated.

Quadrat survey method

The method used for this study was adapted from Taylor *et al.* (1994) who used timed searches of one hour per 10 x 10 m plot, focusing on potential shelter sites of land snails. In this study, 10 x 10 m quadrats also were used and searched for a total of one hour in all potential snail shelter sites. Smith and Kershaw (1979) reported that *Victaphanta compacta* is found in leaf litter, and Taylor (1991) and Taylor *et al.* (1994) list other potential mollusc shelter sites such as logs, the leaf litter around trees and tree-ferns and the tops of ferns. The shelter sites where live snails and dead shells were recorded and classed into four categories included:

1. Leaf litter: snails found on top and underneath open leaf litter;
2. Tree/tree-fern base: snails found around the bases of trees and tree-ferns;
3. Logs: snails found on, around and underneath logs; and
4. Vertical shelter sites: snails found in the crowns of tree-ferns and in the crevices of trees less than two metres in height.

Quadrats were first visually scanned to locate any active snails, then searches for live snails were conducted by overturning leaf litter and logs by hand and by using small gardening forks. The crowns of ferns were searched gently by hand, and logs were overturned by hand. Everything was replaced after searching and it was thought that no snail would be injured or killed by this method. Shell diameters of all live snails were recorded as a measure of age class.

Site selection

Quadrat surveys were conducted in three sites in each of three locations. The locations were chosen by consulting 1:100 000 BIOMAPs and 1:25 000 Topographic maps of the Otway Ranges. Locations were selected first for their suitability of habitat for the snails (Wet forest and Cool Temperate Rainforest) and for their similarity in elevation and aspect. Similar elevation and aspect were needed so that the three locations would be statistically comparable. The three locations chosen for the quadrat surveys were: Mt Sabine Falls (38°37'58"S 143°44'58"E), Beauchamp Falls (38°39'04"S 143°36'25"E), and Grey River Road (38°38'45"S 143°46'10"E).

The elevation at Mt Sabine Falls is 490 m on the ridge, and the location has a SSW aspect. Mt Sabine Falls was surveyed on 28 August, 9 September and 11 September 2004. Beauchamp Falls has an altitude of 440 m on the ridge and a SSE aspect; it was surveyed on 11-12 September 2004. Grey River Road has an elevation of 520 m on the ridge and a SSW aspect; it was surveyed on 21-22 October 2004.

Three habitats were surveyed within each location: ridge, slope and gully habitat. Site 1 – ridge habitat included the ridge top and slope down to 50 metres, Site 2 – slope habitat included the area between the ridge and gully sites and Site 3 – gully habitat included the valley floor, riparian zones and slope up to 50 metres.

Five quadrats were surveyed in each site for a total of 15 quadrats for each location. In each site the quadrats were placed randomly. Forest types were recognised using the criteria set out by Cameron (1992).

Statistical analysis

Univariate ANOVAs were performed using the SPSS 11.0 for Windows program to investigate individual location habitat and shelter site preferences, and the *post hoc* Tukey test was used to detect where

any significant difference lay. Analysis was performed with the guidance of Kirkpatrick and Feeney (2003). Some of the data were recorded as zeros or low numbers; therefore, to normalise the data before statistical analysis, log transformation was used, $X' = \text{Log}(x + 1)$ (Zar 1999).

Results

Habitat preferences

A total of 148 live snails was recorded on the ridges, slopes and gullies at the three locations. Fifty-nine snails were recorded at Mt Sabine Falls with 12 (20.3%) on the ridge, 17 (28.8%) on the slope, and 30 (50.9%) in the gully. At Beauchamp Falls, 49 snails were recorded with 19 (38.8%) on the ridge, 13 (26.5%) on the slope, and 17 (34.7%) in the gully. Grey River Road had 40 snails, with 27 (67.5%) on the ridge, eight (20%) on the slope, and five (12.5%) in the gully.

The data from the three locations was pooled and statistically analysed. No significant difference was detected (P=0.434) between locations and between habitat types. This suggests that the locations were statistically similar in the numbers of snails per habitat type and that *Victaphanta compacta* has no distinct preference for habitat (Wet Forest on ridges, Mixed Forest on slopes, and Cool Temperate Forest in the gully.

Shelter site preferences

The numbers of live *V. compacta* found in each shelter site (base, litter, logs or vertical shelter sites) for the three habitats at the three locations are provided below.

Mt Sabine Falls

In the ridge habitat a total of six (50%) snails was found in the base shelter site, three snalis (25%) were found in leaf litter, two (16.7%) were found in the log shelter site and one (8.3%) was found in the vertical shelter site. In the slope habitat a total of seven (41.2%) snails was recorded for the base shelter site, seven snails (41.2%) were found in leaf litter and three (17.7%) were found in the log shelter site; no snails were recorded in the vertical shelter site. In the gully habitat a total of 16 (53.3%) snails was recorded for the base shelter site, five snails (16.7%) were found in leaf litter, eight (26.7%) were found in the log shelter site and one (3.3%) was found in the vertical shelter site.

Beauchamp Falls

In the ridge habitat a total of 11 (57.9%) snails was recorded in the base shelter site, seven snails (36.8%) were found in the leaf litter and one (5.3%) was found in the log shelter site; no snails were found in the vertical shelter site. The slope habitat had a total of nine (75%) snails in the base shelter site and three (25%) in the leaf litter; no snails were found in the log and vertical shelter sites. The gully habitat had a total of seven (53.9%) snails in the base shelter site and six (46.2%) in the leaf litter; no snails were found in the log and vertical shelter sites.

Grey River Road

The ridge habitat had a total of 11 (40.7%) snails in the base shelter site, 13 (48.2%) in the leaf litter and three (11.1%) in the log shelter site; no snails were found in vertical shelter site. The slope habitat had a total of three (42.9%) snails in the base shelter site and four (57.1%) in the leaf litter; no snails were recorded for the log and vertical shelter sites. The gully habitat had a total of two (40%) snails in the base habitat and three (60%) snails in the leaf litter; no snails were found in the log and vertical shelter sites.

Analyses of the pooled raw data for the three locations showed that *Victaphanta compacta* occurred equally in base shelter sites and leaf litter shelter sites and then log shelter sites and rarely in vertical shelter sites as only two individuals were recorded in this shelter site.

Statistical analysis of the pooled data from the three locations showed a significant difference (P<0.001). A post hoc Tukey test revealed that the difference lay between the overall preferences between shelter sites. Base shelter sites did not significantly differ from leaf litter (P=0.621), base shelter sites significantly differed from logs (P<0.001), base shelter sites significantly differed from vertical shelter sites (P<0.001), leaf litter significantly differed from logs (P=0.006) and from vertical shelter sites (P<0.001). No significant difference was detected between logs and

vertical shelter sites. This suggests that the number of snails within each shelter site did not differ between ridge, slope and gully and between the three locations. However *Victaphanta compacta* showed an overall preference between shelter sites, preferring base and leaf litter shelter sites to log and vertical shelter sites

Discussion

Habitat

Statistical analysis showed that *V. compacta* occurred equally between the three habitats, suggesting that the species has no preferred habitat type between Wet Forest, Mixed Forest and Cool Temperate Rainforest.

Smith (1977) listed the habitats for *Victaphanta compacta* as the Wet Forests and Cool Temperate Rainforests of the Otway Ranges, whereas all other references list the species as only occurring within the Cool Temperate Rainforests including Gabriel (1930), Smith (1970), Smith and Kershaw (1979) and the *Flora and Fauna Guarantee Act 1988* (SAC 2001) under which the species is listed as 'Threatened' because of its restricted habitat (i.e. Cool Temperate Rainforests in the Otway Ranges). However the present study has not only supported Smith's (1977) recording of Wet Forests as well as Cool Temperate Rainforests in the Otway Ranges as *V. compacta's* habitat, but it has also suggested that the species occurs equally within these habitat types and in the boundaries between the two (i.e. Mixed Forests).

Shelter Sites

Statistical analysis of the combined data revealed that *Victaphanta compacta* showed a preference between the four shelter sites surveyed in this study. The species was found to be equally occurring around the bases of trees and tree ferns as well as leaf litter and was less likely to be found in the log shelter sites. The study recorded that *V. compacta* is unlikely to be recorded in sites that are above the ground up to two metres suggesting that the species is not arboreal.

Smith and Kershaw (1979) reported that *Victaphanta compacta* could be found in the leaf litter in the Cool Temperate Rainforests of the Otway Ranges. The present study found this to be true and expanded it to include areas around the base of trees and tree ferns and to a lesser extent logs in both Cool Temperate Rainforests and Wet Forests of the Otway Ranges.

The present study found that *V. compacta* prefers the base of trees and tree ferns and leaf litter, rather than log shelter sites and rarely vertical heights. The endangered New Zealand carnivorous land snail, *Paryphanta busbyi watti*, also hides under leaf litter in dense vegetation during the day (Stringer *et al.* 2003). That the logs are not a significant shelter site for *V. compacta* is interesting, as for most invertebrates, logs are an important aspect of their habitat requirements (Taylor 1991; Taylor and Doran 2001). In the case of *V. compacta*, it is still unknown whether logs may affect environmental conditions that enable this species to inhabit these forests.

Other observations

Most Rhytididae snails are nocturnally active (Smith 1998), but some are active during the day in wet weather (Meads *et al.* 1984). *Victaphanta compacta* is primarily nocturnal, but during this study 62 individuals were found to be active during the day; however, all observations were on days of wet weather. The mating behaviour of some carnivorous land snails can take several days (Stringer *et al.* 2003); four pairs of mating *V. compacta* were observed during September in this study, and Fig. 2 shows a mating pair connected by their everted reproductive organs.

Conclusions

This project assessed the distribution of the Otway Black Snail in different topographies in the Otway Ranges. It was found in Temperate Rainforest (gullies), Wet Forests (ridges) and in the ecotone between these two (slope). Within these areas, *V. compacta* was found predominantly around the base of trees and in leaf litter. This suggests that leaf litter is an important microhabitat for this species, and factors that threaten the leaf litter layer could have adverse effects on *V. compacta*.

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Freshwater and terrestrial crayfish (Decapoda, Parastacidae) of Victoria: status, conservation, threatening processes and bibliography

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Abstract
The freshwater crayfish of Victoria are identified and their current conservation status updated. Literature references on Victorian crayfish taxa and their conservation and taxonomy are identified. The distribution and status of each species is indicated for Victoria. Known and potential threats acting on Victorian crayfish are discussed. Distribution maps of crayfish species occurring in the state are provided for most taxa. (*The Victorian Naturalist* **124** (4), 2007, 210-229)

Introduction

Over 85% of the known species of parastacid crayfish have been recorded from Australia, with more than 100 species currently recognised in nine genera (Horwitz 1995a; Jones and Morgan 2002; Davie 2002; Austin *et al.* 2003; Van Praagh 2003a). Biologists know that crayfish play an important role in the breakdown of organic matter in aquatic ecosystems (Lorman and Magnuson 1978). Crayfish also are a major food source for vertebrates higher up in the food chain, e.g. fish and platypus (Zampatti and Close 2000). South-eastern Australia has been recognised as a 'biodiversity hotspot' for endemic freshwater crayfish (Reik 1969; Whiting *et al.* 2000; Harvey 2002) with some habitats holding multiple species within small geographic ranges (e.g. Morey and Hollis 1997). The reasons for this high level of short-range endemism among crayfish include: poor powers of dispersal, low recruitment, confinement to discontinuous habitats, and slow maturation rates (Harvey 2002). Merrick (1995) made management recommendations to address the conservation of a number of New South Wales freshwater crayfish. Many of these recommendations are equally relevant to Victoria. The current paper is essentially a review of current information and aims to (i) review the current distribution of Victorian crayfish, (ii) indicate the status and conservation information of Victorian crayfish, (iii) update previous conservation assessments for Victorian crayfish species mentioned in Horwitz (1990a) and Merrick (1995) and (iv) provide Victorian distribution maps of crayfish species occurring in Victoria. Merrick (1993, 1995) looked at freshwater crayfish in New South Wales and Zeidler (1982) provided information on crayfish occurring in South Australia. Yet there is no recent paper covering the crayfish fauna of Victoria. This paper addresses only the Victorian crayfish fauna. Freshwater crabs and other crustacea are not included.

Victorian crayfish diversity

The broad types of land and aquatic crayfishes recorded from Victoria have been well known since at least the 1930s (Clark 1936a, 1936b, 1938). Victorian freshwater crayfish comprise the following genera (number of Victorian species in brackets): *Cherax* ('smooth yabbies', two species), *Engaeus* ('burrowing crayfish', 22 species), *Euastacus* ('spiny crayfish', 11 species), *Geocharax* ('land crayfish', two species) and *Gramastacus* ('swamp crayfish', two species). The *Engaeus* and *Euastacus* genera share the bulk of the crayfish species recorded from Victoria (Table 1).

Crayfish are heavy-bodied crustaceans with their first pair of legs enlarged and pincer-like. They belong to the Order Decapoda and family Parastacidae and are commonly known as 'yabbies', which usually only refers to *Cherax* species, but this term actually covers the above five groups. Victorian freshwater crayfish species can be divided into three main groups according to their habits, aquatic, semi-aquatic and terrestrial (Clark 1938; Rogan 1972)

Table 1: Victorian crayfish genera and main taxonomic/distribution references to 2005.

Parastacid group	Common name	No. spp. in Victoria	Major taxonomic papers (* = these papers provided illustrations of some species)
Cherax	yabbies	3	Smith 1912*, Reik 1969*, Sokol 1988, Austin 1996, Lawrence *et al.* 2002, Austin and Ryan 2002 (Marron), Austin *et al.* (2003), Munasinghe *et al.* (2004), Nguyen *et al.* 2004.
Engaeus	burrowing crayfish	22	Smith and Schuster 1913*, Reik 1969*, Horwitz 1990a, 1995b
Euastacus	spiny crayfish	11	Smith 1912*, Clark 1941a,b*; Reik 1969*, Morgan 1986*, 1997*
Geocharax	land crayfish	2	Clark 1941b
Gramastacus	swamp crayfish	2	Clark 1941b*, Reik 1972*, Zeidler & Adams 1990*

as well as their habitats (see Table 2). The aquatic forms inhabit running water and are the spiny freshwater crayfish (genus *Euastacus*), which are found across most of the state. The best known species of this genus is probably the Murray Spiny Crayfish *Euastacus armatus*. They are characterised by sharp spines on the body and claws of the adults. Claws are also white in adult *E. armatus*. Spiny freshwater crayfish can be further divided ecologically into two broad groups (Morgan 1997), one comprising species occurring at lower altitudes (typically the lowlands e.g. Murray Spiny Crayfish) and the second group which tends to occur at much higher altitudes (in cool, clear waters often with an associated thick riparian vegetation (e.g. Alpine Spiny Crayfish *E. crassus*). Most spiny crayfish have extremely localised ranges (Harvey 2002), often restricted to single catchments or sub-catchments.

Semi-aquatic crayfish inhabit streams, lakes, dams etc. and are adapted to the naturally unpredictable nature of water availability in Australia, so that when water bodies become dry they burrow underground to reach moister conditions until the next rains. This group can live for some time out of water and also travel overland to other water bodies. They tend to be smaller than the true aquatic forms (125-150 mm when fully grown) and lack spines on the body. The best known example of this group are the yabbies (genus *Cherax*) (Kailola *et al.* 1993). In this paper the term 'yabby' refers only to the *Cherax* species.

Terrestrial forms live in burrows or shafts in marshy ground, river banks or hilltops. Shafts can be a metre or more deep and often the entrance is marked by a conical heap of excavated soil or mud. The shafts end in underground cavities that are partly or fully filled with water or liquid mud. The terrestrial forms are the smallest of the freshwater crayfish with the length of a fully grown adult around 50-75 mm. In Victoria, this group comprises the burrowing crayfish (genus *Engaeus*) and the land crayfish (genus *Geocharax*).

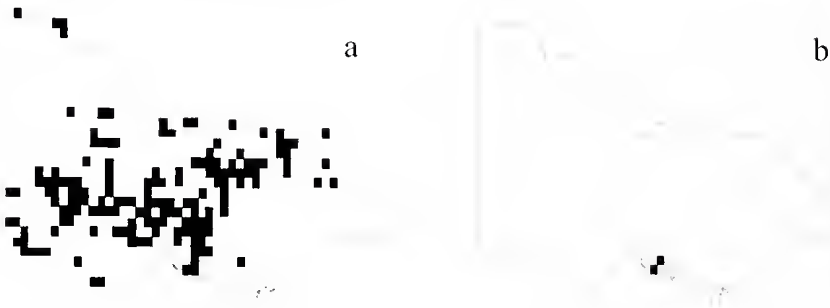
A number of Victorian crayfish (mainly the larger species i.e. crayfish growing to more than a kilogram in weight) are the target of recreational fishing, e.g. Murray Spiny Crayfish, (Clark 1936a); Gippsland Spiny Crayfish, (Morey 1998) and Glenelg Spiny Crayfish, (Van Praagh 2003a). These species tend to be slow-maturing and long-lived (Barker 1990) and are well known amongst anglers for their eating qualities. For example, the Murray Spiny Crayfish has been sold in the Melbourne market since the early 1900s and has been reported as '...superior in flavour and texture..' compared to its marine cousins (Smith 1912). The Murray Spiny Crayfish has declined in range and abundance since the 1940s. Habitat degradation is the main cause for this decline (Barker 1990; Suter and Hawking 2002) although recent overfishing has also taken a substantial toll (Sharp 1995). It is thought to have disappeared downstream of Mildura (with increasing salinity implicated in its decline) and is possibly extinct in South Australia (Walker 1982; Jackson 1997). Geddes and Mitchell (1987) published a paper on reintroduction of Murray Crayfish to river stretches whence they had

Table 2: Victorian freshwater and terrestrial crayfish species: 2005 taxonomy, distribution and conservation status (updated information, sourced from: Horwitz 1995b, Horwitz pers. comm., Raadik pers. comm.; International Union for the Conservation of Nature data). Key: underlined species = on the list of threatened taxa under the *Flora and Fauna Guarantee (FFG) Act;* **bold** = endemic Victorian taxa; R? = not classified but suspected to be rare and/or threatened (N.B. No Victorian crayfish have so far been nominated for listing under the Commonwealth EPBC Act.); RRS = restricted (limited distribution) range species; B = broad range species (wide geographical distribution). Conservation status - Lower case (in Victoria): e = endangered, v = vulnerable, r = rare, k = insufficiently known (suspected rare, vulnerable or endangered) (source: CNR 1995a). Upper case (in Australia, IUCN categories): E = endangered, V = vulnerable (-) status unknown or not assessed (source: Department of Environment and Heritage web site 2007).

Scientific name and reference	Common name	General locality	Conservation status Vict	Range	Aust
Genus ***Cherax***					
Cherax rotundus (Barmah) Clark 1963a Austin *et al.* 2003	Murray Swamp Yabby	Central northern Victoria and possibly Southern NSW adjacent to Murray River	k/R?	RRS	-
Cherax destructor albidus Austin *et al.* 2003	Common Yabby	South-western Victoria and far South-eastern SA, and translocations	-	B	V
Cherax tenuimanus Smith 1912	Marron	Natural range is Western Australia, a recent record of an introduction to Victoria	-	-	-
Genus ***Gramastacus***					
<u>*Gramastacus insolitus*</u> Riek 1972, Zeidler & Adams 1990	Western Swamp Crayfish	South-western Victoria and far South-eastern SA	v	RRS	-
Gramastacus sp. (undescribed) Horwitz 1995b	Crayfish species	Central northern Victoria (Shepparton/Barmah region)	-	RRS	-
Genus ***Geocharax***					
Geocharax falcata Clark 1936b	Western Crayfish	South-western Victoria, North-western Tasmania, western Bass Strait islands	-	RRS	-
Geocharax gracilis Clark 1936b	Otways Crayfish	South-western Victoria (Otway Ranges), North-western Tasmania, western Bass Strait islands	-	RRS	-
Burrowing Crayfish **(22 species)**					
Genus ***Engaeus***					
Engaeus affinis Smith and Schuster 1913	Central Highlands Burrowing Crayfish	Central eastern Victoria	-	RRS	-
Engaeus australis Riek 1969	Lilly Pilly Burrowing Crayfish	Wilsons Promontory	r	RRS	E
Engaeus cunicularius Erichson 1846	Granular Burrowing Crayfish	South Gippsland, Bass Strait, including islands, Tasmania	-	B	-
<u>***Engaeus curvisuturus***</u> Horwitz 1990a	Curve-tail Burrowing Crayfish	Central eastern Victoria	R?	RRS	E
Engaeus cymus Clark 1936a	North-eastern Burrowing Crayfish	Central eastern Victoria, to ACT and adjacent NSW districts	-	B	-
Engaeus fultoni Smith and Schuster 1913	Otway Burrowing Crayfish	restricted to Otway Ranges	R?	RRS	-
Engaeus hemicirratulus Smith and Schuster 1913	Gippsland Burrowing Crayfish	South and central Gippsland	-	RRS	-
Engaeus karnanga Horwitz 1990b	South Gippsland Burrowing Crayfish	South Gippsland	R?	RRS	-
Engaeus laevis Clark 1941b	Richards Burrowing Crayfish	South and East Gippsland, Tasmania	-	RRS	-

Table 2. cont'd

Scientific name & reference	Common name	General locality	Conservation status Vict	Range	Aust
Engaeus lyelli Clark 1936	Upland Burrowing Crayfish	Central and Western Victoria	-	B	-
Engaeus mallacoota Horwitz 1990a	Mallacoota Burrowing Crayfish	Far eastern Victoria (and probably far Southern NSW)	R?	RRS	E
Engaeus merosetosus Horwitz 1990a	Western Burrowing Crayfish	Corangamite/Otways district	R?	RRS	-
Engaeus orientalis Clark 1941	East Gippsland Burrowing Crayfish	Eastern Victoria (East Gippsland and far Southern NSW)	-	RRS	-
Engaeus phyllocercus Smith and Schuster 1913	Narracan Burrowing Crayfish	Warragul/Narracan districts	R?	RRS	V
Engaeus quadrimanus Clark 1936a	Lowland Burrowing Crayfish	Melbourne to Mallacoota	-	B	-
Engaeus rostrogaleatus Horwitz 1990b	Strzelecki Burrowing Crayfish	Strzelecki Ranges	r	RRS	E
Engaeus sericatus Clark 1936a	Hairy Burrowing Crayfish	Otways and Portland districts	-	RRS	-
Engaeus sternalis Clark 1936a	Warragul Burrowing Crayfish	Only at Tarago, South Gippsland	e	RRS	E
Engaeus strictifrons Clark 1936a	Portland Burrowing Crayfish	South-western Victoria	-	RRS	-
Engaeus tuberculatus Clark 1936a	Tubercle Burrowing Crayfish	South Gippsland	-	RRS	-
Engaeus urostrictus Riek 1969	Dandenong Burrowing Crayfish	Dandenong Ranges	R?	RRS	E
Engaeus victoriensis Smith and Schuster 1913	Foothill Burrowing Crayfish	South Gippsland	-	RRS	-
Spiny Crayfish (11 Species) Genus ***Euastacus***					
Euastacus armatus von Martens 1866	Murray Spiny Crayfish	Northern Victoria, South-eastern SA, ACT and central southern NSW	k	B	V
Euastacus bidawalus Morgan 1986	East Gippsland Spiny Crayfish	East Gippsland and far south-eastern NSW	-	RRS	-
Euastacus bispinosus Clark 1936a	Glenelg Spiny Crayfish	Far south-western Victoria and south-eastern SA	k	RRS	V
Euastacus claytoni Riek 1969	Clayton's Spiny Crayfish	East Gippsland (Bendoc?) and South-eastern NSW (Craigie area)	-	RRS	-
Euastacus crassus Riek 1969	Alpine Spiny Crayfish	Australian Alps, (ACT, south-eastern NSW and northern Victoria)	r	RRS	E
Euastacus diversus Riek 1969	Orbost Spiny Crayfish	East Gippsland	v	RRS	E
Euastacus kershawi Smith 1912	Gippsland Spiny Crayfish	South-eastern Victoria (La Trobe River to East Gippsland)	r	B	-
Euastacus neodiversus Riek 1969	South Gippsland Spiny Crayfish	Far South Gippsland	r	RRS	V
Euastacus woiwuru Morgan 1986	Central Victorian Spiny Crayfish	South-eastern Victoria	-	B	-
Euastacus yanga Morgan 1997	Variable Spiny Crayfish	Far East Gippsland (Genoa River) and NSW	-	RRS	-
Euastacus yarraensis McCoy 1888	Southern Victorian Spiny Crayfish	Tarago River to Otways	-	RRS	-
Euastacus sp. nov. (Edney pers. comm.)	'Buffalo Spiny Crayfish'	Buffalo River catchment	-	RRS	-



Distribution maps of *Cherax* species. a. *Cherax destructor*. b. *Cherax tenuimanus*.

disappeared. Other Victorian crayfish subjected to angling pressure are the Yarra River Spiny Crayfish *Euastacus yarraensis* and the East Gippsland Spiny Crayfish *E. bidawalus* (Barker 1990). No recreational take figures are kept or gathered for Victorian crayfish, but by far the main target of many crayfish anglers has been the widely-distributed Yabby *Cherax destructor*, which occurs across most of lowland Victoria (Kailola *et al.* 1993; DSE 2006). Some figures for yabbies sold at the Melbourne Fish Market are, 1979 – 10.92 tonnes, 1980 – 17.92T, 1981 – 13.41T (Department of Sustainability and Environment unpublished data, DSE file 84-3692), many of these may have been artificially grown in ponds. The commercial catch of yabbies has also been increasing (ENRC 2000) viz. 1994 – 6.3T, 1995 – 6.1T, 1996 – 17.3T and 1997 – 25.5T. Aquaculture production for yabbies is far greater than the wild harvest, but the wild harvest is also growing (ENRC 2000).

Accounts of Australian crayfish biology (limited morphology, habitat and distribution information) are provided for some species by Smith and Schuster (1913), Clark (1936b, 1938), Barker (1990), Merrick (1993), Gooderham and Tsyrlin (2002) and Jones and Morgan (2002). Many detailed (mainly taxonomic) accounts have also been published for the various genera and species (Table 1). Crandall *et. al.* (1999) provide general distribution maps for all the Australian parastacid groups. Jasinka *et al.* (1993) looked at the spread of the Yabby in Western Australia. Doran (1999) and Doran and Richards (1996) looked at rare and threatened Tasmanian crayfish. The crayfish taxonomy used in this paper follows that described by Horwitz (1995b) and Davie (2002). Horwitz (1995b) recognised the following number of taxa in Australia: *Cherax* (22 species), *Engaeus* (35), *Euastacus* (37), *Geocharax* (2), *Gramastacus* (2). Until further electrophoretic studies are carried out to decipher all Australian freshwater crayfish, this is unlikely to be the final list for Victorian species.

The biology of most indigenous parastacid crayfishes currently known to occur in Victoria is still poorly known. Many species have highly restricted geographic ranges and are good examples of 'short-range-endemics' (SREs) (Harvey 2002) (Table 3). Most studies on Australian crayfish have been directed at their taxonomy (see references in Table 1). The ecology of some species of Victorian freshwater crayfish have been described (e.g. Hoey 1990; Koster *et al.* 1999; burrow classification, Horwitz and Richardson 1986) but much remains unknown about this diverse group of native crustaceans. To date, an analysis of most Victorian freshwater crayfish distributions in relation to conservation reserves has not been carried out (Van Praagh and Hinkley 1999) and most species are not adequately protected within any National or State Park or any streamside conservation reserve.

Horwitz (1990a, 1990b, 1995b) assessed the conservation status of many Australian parastacids, including south-east Australian taxa. In Victoria, a small number of invertebrates were most recently addressed with formal conservation classifications in 1995 (CNR 1995a) while Butcher and Doeg (1995) specifically assessed aquatic Victorian invertebrates

Table 3: Distribution and general habitat of Victorian freshwater crayfish genera.

Genus	Group name	Size	Victorian distribution	Example	General habitat
Aquatic					
Euastacus	spiny crayfish	large	across Victoria	Murray and tributaries, Glenelg, Yarra and Gippsland Rivers	Cool water and strong flowing streams
Gramastacus	swamp crayfish	medium - large	isolated occurrence, Western Victoria	southern Grampians	Freshwater swamp margins
Semi-aquatic					
Cherax	yabbies	medium - small	across mainly inland Victoria, widely distributed and translocated	Billabongs and backwaters of northern river floodplains	Warm water of slow-flowing streams, active in warmer months
Terrestrial					
Engaeus	burrowing crayfish	small	Southern, mainly coastal, Victoria	Dandenong Ranges, Healesville/ Warburton area, Warragul district, Otway Ranges	Damp soil in riparian habitats and forest
Geocharax	land crayfish	small	restricted to south-western Victoria	Grampians	Freshwater swamps

(including some crayfish). Since 1995 a number of Victorian crustaceans have been added to the list of threatened taxa under the *Flora and Fauna Guarantee Act* 1988 (FFG) (SAC Database 2007). All the currently known rare or threatened Victorian crayfish species are now listed (Table 4). As a result of these listings most crayfish species listed in Victoria now have a published management plan (or Action Statement).

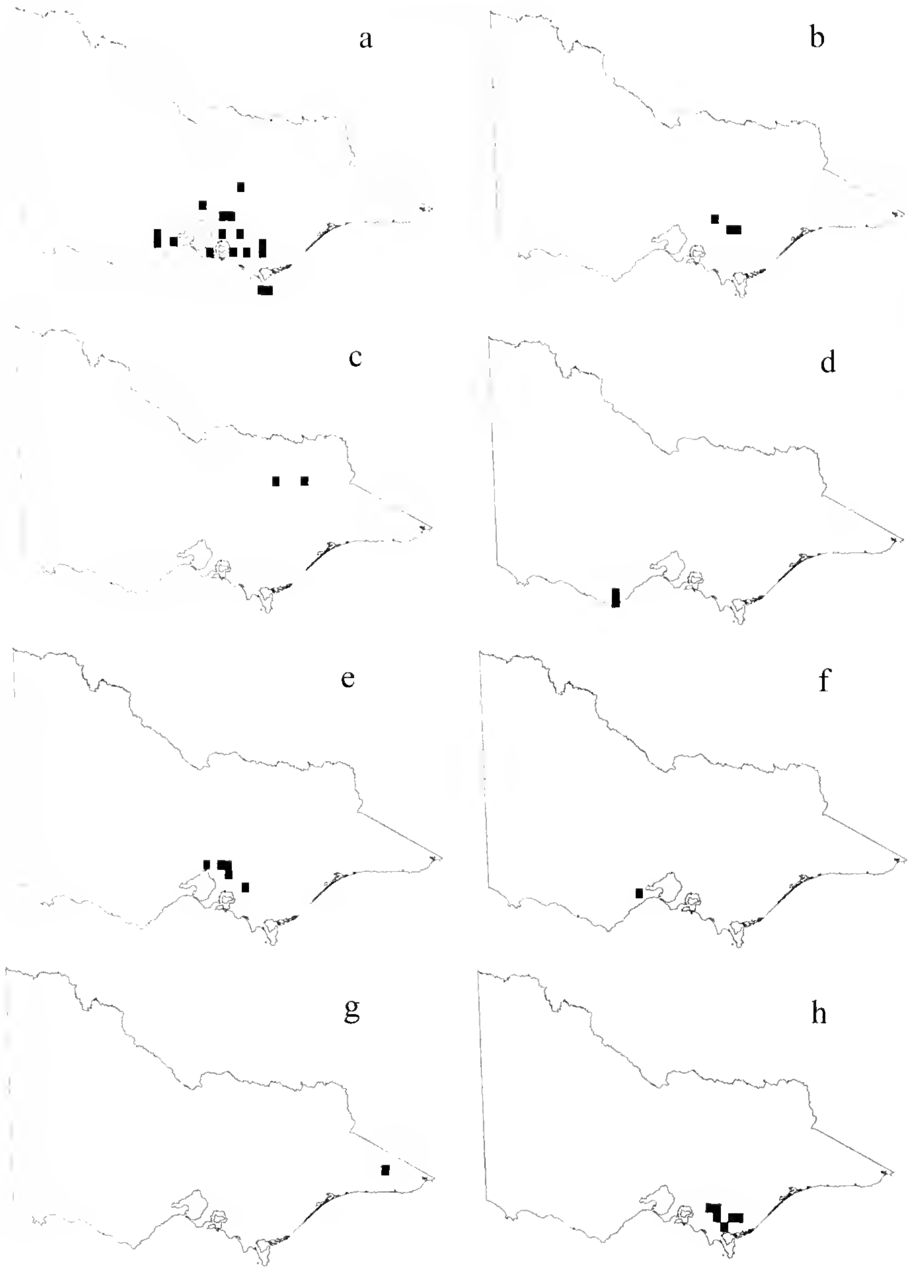
There are no recently published accounts or comprehensive summaries of Victorian crayfish, their conservation status, processes threatening their existence or the management actions directed at specific taxa. Horwitz (1995b) is the only researcher who has summarised the conservation status of selected Australian freshwater crayfish, but the information published is now over 10 years old. Though now dated, Merrick (1991) provided a bibliography of Australian crayfish conservation. Both the Horwitz and Merrick papers are now dated and their information limited, covering only a few of the Victorian species.

Victorian crayfish species

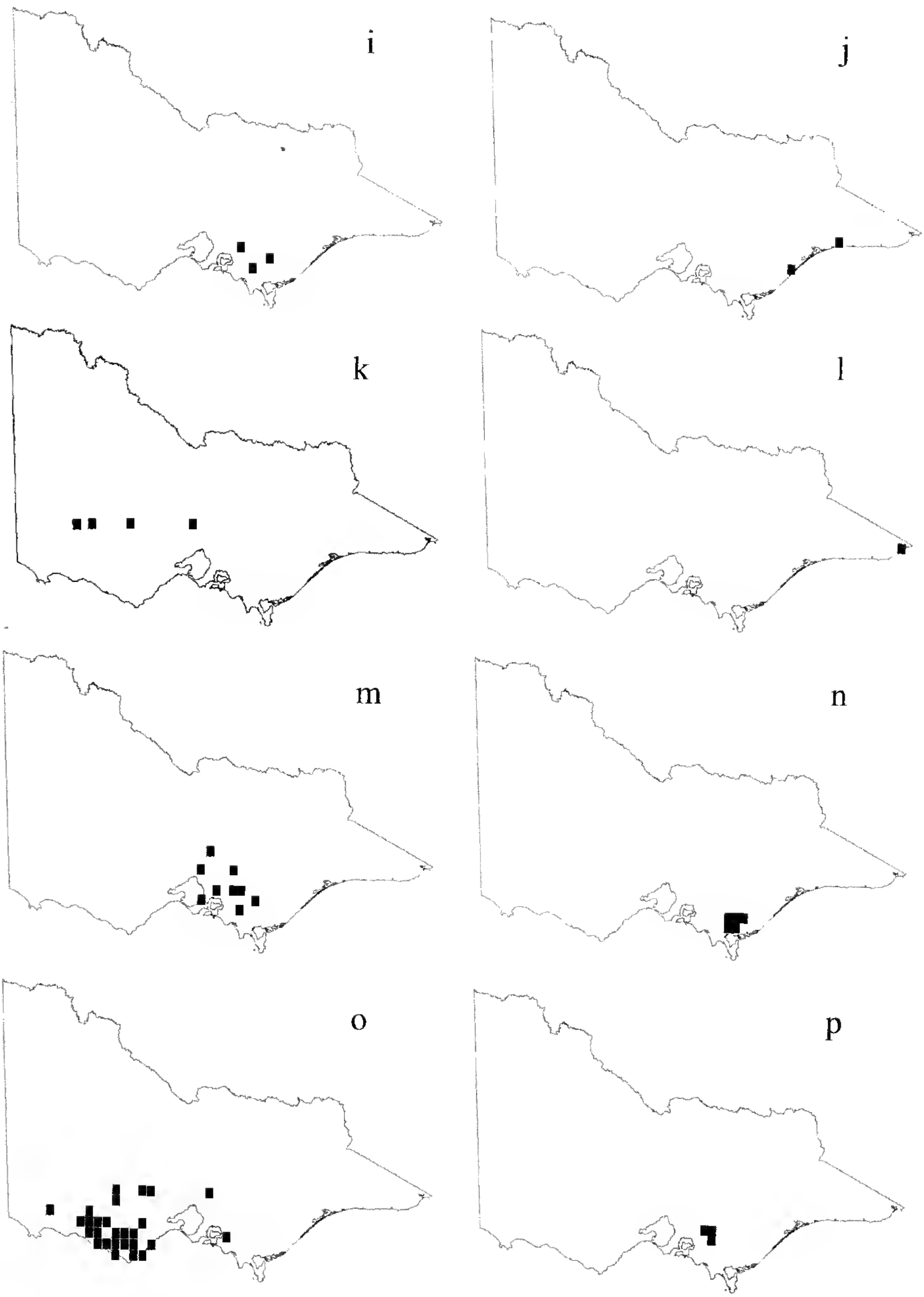
There are no recent papers which identified all the known Victorian crayfish species nor is there any account of the conservation status of Victorian crayfish. However, Yen and Butcher (1997) examined the conservation of non-marine invertebrates in Australia, and a number of Victorian crayfish taxa with their conservation status were addressed in that report. There are currently (2007) 39 species of freshwater or land crayfish recorded for Victoria, of which 23 are endemic (Table 3). There also is at least one undescribed species known to occur in the state [Murray Swamp Yabby (Barmah) *Cherax rotundus*]. The taxonomy of *Cherax* has been the subject of much discussion amongst crayfish researchers (e.g. *Cherax* occurring in northern Victoria, Austin *et al.* 2003). There are recent records of the West Australian Marron *Cherax tenuimanus* from illegal introductions into Victoria (Raadik pers. comm.). This is currently the only known exotic species in Victoria. Marron has been declared a noxious species in Victoria (DPI 1998).

Conservation status of Victorian Crayfish

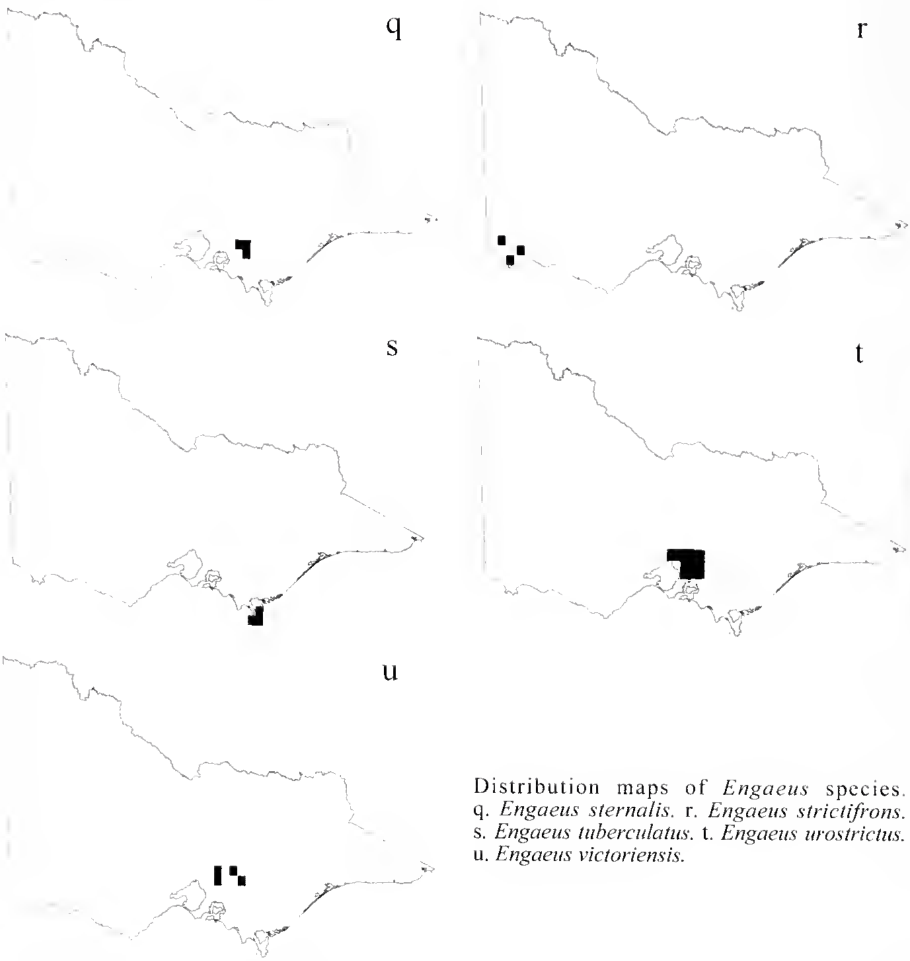
In Victoria, the key piece of legislation for the identification, assessment and listing of threatened species is the *Flora and Fauna Guarantee Act* 1988. Threatened species and communities of flora and fauna were added to schedule 2 of the Act after an independent advisory committee (the Scientific Advisory Committee or SAC, which comprises various scientific experts) assesses the public nominations. In addition to this Act, the (Victorian) Department of Sustainability and Environment (DSE)



Distribution maps of *Engaeus* species. a. *Engaeus australis*. b. *Engaeus cunicularius*. c. *Engaeus curvisuturus*. d. *Engaeus cymus*. e. *Engaeus fultoni*. f. *Engaeus hemicirratulus*. g. *Engaeus karnanga*. h. *Engaeus laevis*.



Distribution maps of *Engaeus* species. i. *Engaeus lyelli*. j. *Engaeus mallacoota*. k. *Engaeus merosetosus*. l. *Engaeus orientalis*. m. *Engaeus phyllocercus*. n. *Engaeus quadrimanus*. o. *Engaeus rostrogaleatus*. p. *Engaeus sericatus*.



Distribution maps of *Engaeus* species. q. *Engaeus sternalis*. r. *Engaeus strictifrons*. s. *Engaeus tuberculatus*. t. *Engaeus urostrictus*. u. *Engaeus victoriensis*.

maintains management lists of threatened flora and fauna, including terrestrial, freshwater and marine taxa (DSE 2003) although there is currently no similar list maintained for invertebrates. Most Australian states and territories do not have a list of threatened invertebrate species (Jackson 1997). The last official Victorian Government list that included crustaceans and/or invertebrates is now over 10 years old (CNR 1995a). A new threatened invertebrate list is in preparation in Victoria (DSE in prep.). These latter lists are primarily used as a guide for crown land managers and the public and have no associated legislative requirements with respect to conservation programs to address threatened species.

Many invertebrate researchers believe that to conserve threatened invertebrate fauna the emphasis on legislation should be in habitat conservation and reduction in threatening processes rather than focusing on individual taxa (e.g. Butcher and Doeg 1995; Yen and Butcher 1997). A number of workers recognise the merit in identifying 'flagship' species (Butcher and Doeg 1995; Horwitz 1995a) as a means of focusing conservation efforts on those taxa that share similar habitat types and experience similar threatening processes. The distribution of and threats to most of Victoria's crayfish fauna have been documented, but little is published.

Few attempts have been made to conserve crayfish habitat. The only reported

instance of this occurring in Victoria was the nomination and subsequent listing of Warragul Burrowing Crayfish *Engaeus sternalis* habitat under the National Estate assessment process more than a decade ago (Greenslade 1994). This habitat conservation assessment was directed mainly at a small part of *E. sternalis* habitat (a creek bank in a council reserve), but was useful in raising public awareness of native crayfish and their conservation in Victoria (CNR 1995b). There has not been any similar conservation assessment examining the habitat of any other Victorian terrestrial/ freshwater invertebrates.

Crayfish management issues in Victoria

Government policies on crayfish management in Victoria have changed over the years. In the late 1980s the Department of Conservation Forests and Lands (now DSE) advised people experiencing problems with burrowing crayfish on their properties as follows: 'Burrowing crayfish are generally regarded by the public as a nuisance and treated accordingly. To a large extent this attitude is reflected by (the) department and we have no policies on them (crayfish). We issue advice on methods of extermination' (Horwitz 1990b, p. 24).This advice has included the use of tar creosote, carbon bisulphide, malathion or caustic soda being poured into crayfish burrows.

In recent years many Victorian crayfish species have been added to the list of threatened fauna under the *Flora and Fauna Guarantee Act*. This has resulted in a number of controls on the take of crayfish being implemented in Victoria under the *Fisheries Act 1995* (e.g. Fishing [Spiny Freshwater Crayfish] Regulations 1991, see Fisheries Notice 5/2000 in references). Such regulations specify the minimum allowable size of Spiny Freshwater Crayfish that can be taken in Victoria and also what species can be taken and how (i.e. gear used) and when crayfish may be taken (collected by anglers).

Land subsidence

Burrowing crayfish

Engaeus species occurring in some urban areas have been recorded as the cause of major land subsidence (Clark 1936a, 1936b, 1938; Rogan 1972), particularly in the highland areas east of Melbourne (e.g. Dandenong Ranges) where there have been calls from land owners and developers about burrowing crayfish undermining house foundations and causing the sinking or subsiding of agricultural lands. The Melbourne Museum has published an information sheet for the public on this issue (Museum Victoria 2005).

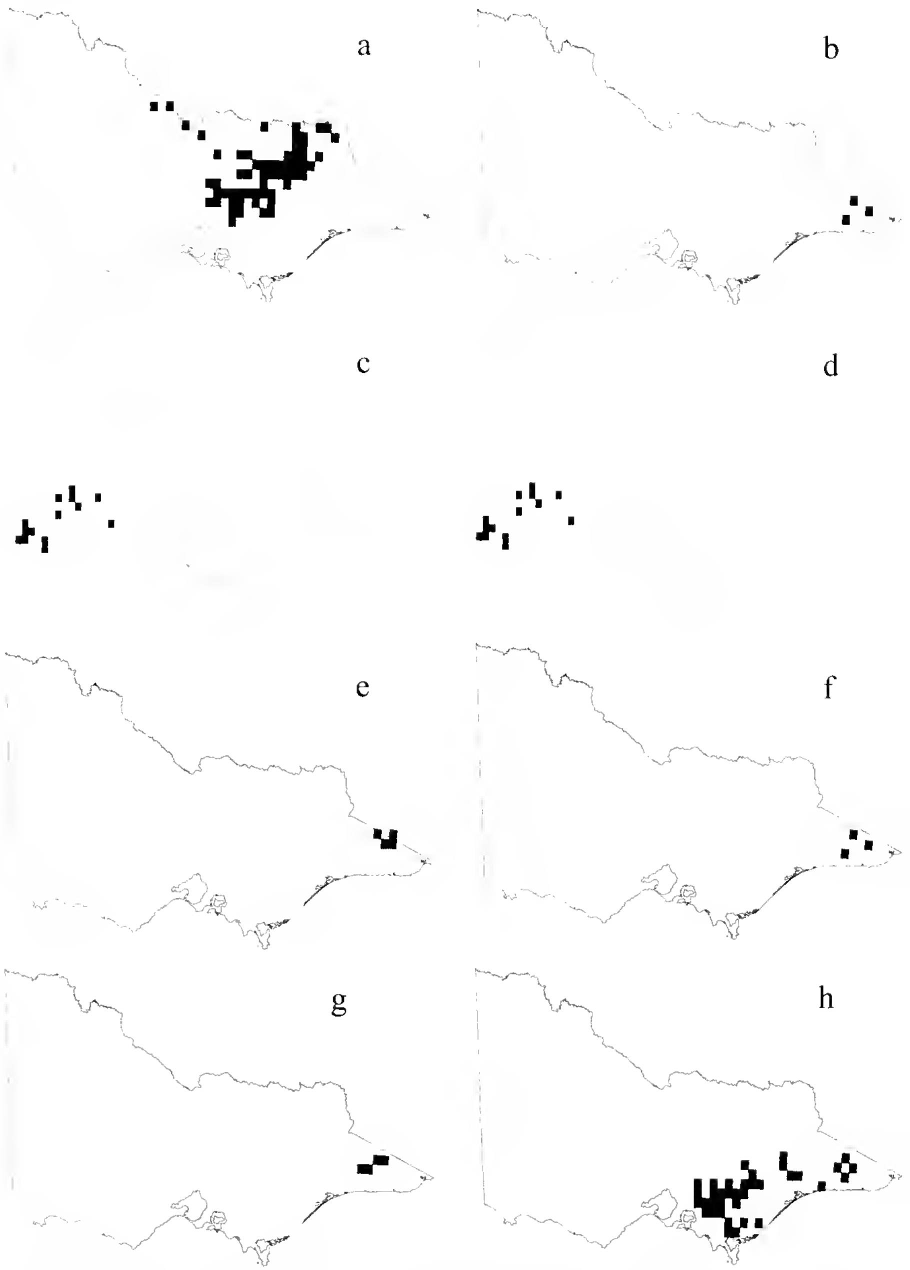
Yabbies

Problems caused by yabbies also have been reported historically from rural Victoria where crayfish (most likely *Cherax* species) have been recorded '... in some pastoral districts ... large communal burrows are numerous and collapse under the weight of cattle and horses. At Whitegate, a few miles from Benalla, some areas riddled by yabbies (holes) are practically useless and are known as 'crab-hole country' (Clark 1936b). Land subsidence issues caused by crayfish activity in lowland areas of the state have declined in recent years, presumably caused by agricultural practices causing local extinctions of those burrowing species.

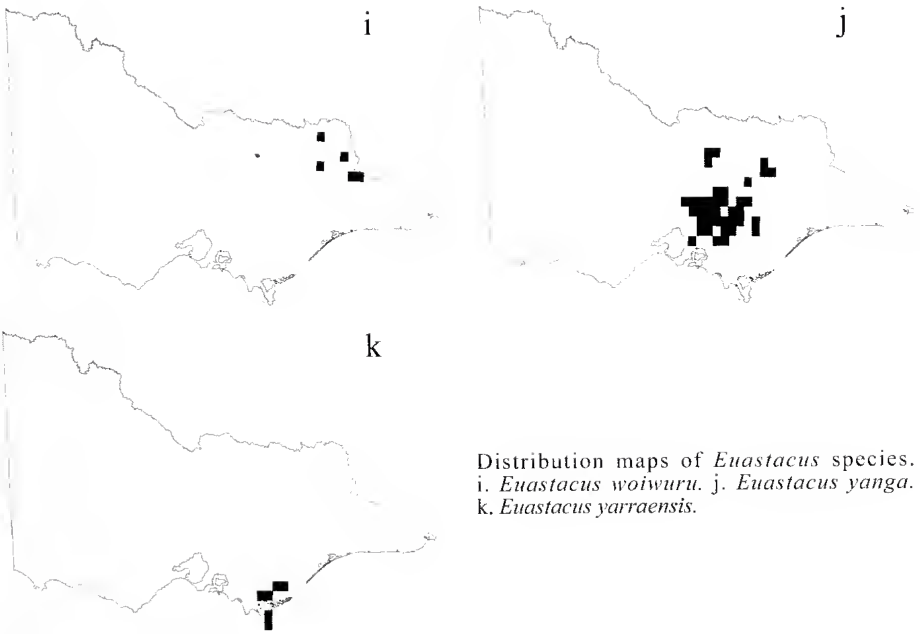
Decline of crayfish

In the 1990s, Horwitz (1990b) identified 33 species of crayfish as threatened in Australia; this included a few Victorian species. To date, no formal conservation assessment has been done on all Victorian crayfish species. The number of crayfish now recognised as threatened in Australia is now likely to be higher since both Victoria and Tasmania have recently assessed many spiny and burrowing species for listing under their threatened species legislation (Horwitz 1994).

A number of Victorian crayfish have experienced declines in both range and abundance. One well documented is the Murray Spiny Crayfish *Euastacus armatus*. The species used to occupy a range of about 800 km, which included most of the Murray River and its tributaries in NSW, Victoria and South Australia (Clarke and Spier-Ashcroft 2003). This was the widest range of any crayfish in the genus. The species is possibly extinct in South Australia (Walker 1982; Barker 1990; Jones and Morgan 2002), and recent records of the taxon in Victoria have been only from upper sections of north-flowing streams (DSE 2006).



Distribution maps of *Euastacus* species. a. *Euastacus armatus*.b. *Euastacus bidawalus*. c. *Euastacus bispinosus*. d. *Euastacus claytoni*. e. *Euastacus crassus*. f. *Euastacus diversus*. g. *Euastacus kershawi*. h. *Euastacus neodiversus*.



Distribution maps of *Euastacus* species. i. *Euastacus woiwuru*. j. *Euastacus yanga*. k. *Euastacus yarraensis*.

Populations of the Gippsland Spiny Crayfish *E. kershawi* have been reduced by overfishing and land development (Jones and Morgan 2002) while populations of the Glenelg Spiny Crayfish *E. bispinosus* have been severely reduced by overfishing, riparian degradation and siltation (Jones and Morgan 2002). The impacts of drought, pollution and increasing salinity are also likely to have contributed to the decline of some riverine crayfish. Table 4 indicates the various threats known to be operating on certain freshwater crayfish in Victoria.

Crayfish species of particular conservation concern

Many native crayfish are naturally rare, i.e. they have a small/restricted geographical range. For example 18 species of burrowing crayfish (e.g. *Engaeus mallacoota*) occur in very narrow geographic ranges (Horwitz 1995a, Table 2), which makes them vulnerable to man-made disturbances, particularly those activities affecting water quality and availability of water (e.g. earth works and movements, cultivation, effects of stock, clearing of riparian vegetation). Other species (e.g. Warragul Burrowing Crayfish) appear to have very specific habitat requirements that may restrict them to certain localities .

As part of a community education and awareness program implemented by the Department of Conservation and Natural Resources in 1995 (CNR 1995b), an information brochure on the Warragul Burrowing Crayfish was distributed to all landholders within the Labertouche Creek catchment in Gippsland, and meetings were held with landholders and the local Labertouche Landcare group (Morey 1999). One of the outcomes of this project was the fencing of crayfish habitat (Morey 1999). One site with some remnant vegetation known to support the species was recommended for reservation as an 'area of natural interest' by the Land Conservation Council in 1994 (Morey 1999). This was supported by Shaw (1996) and Morey (1999). However, to date, this proposed Labertouche Creek Flora and Fauna Reserve has not been formally gazetted.

The habitat ranges of spiny crayfish are often separated by either steep ridges or areas of lower, flatter country (Morgan 1997). Crayfish found at low altitudes (all species) are susceptible to changes occurring in lowland riverine habitats (clearing, salinisation, pollution/urbanisation impacts, recreational fishing and river regulation) while the highland taxa are often threatened by the impacts of forestry and

Table 4: Status of threatened Victorian freshwater crayfish listed under the *Flora and Fauna Guarantee Act* 1988 only species recommended for listing under the Act as at 2007. Key: SAC = Scientific Advisory Committee; A = agriculture; B = burning; D = wetland drainage; F = forestry/loss of riparian vegetation; RF = recreational fishing; S = instream structures/river regulation; P = introduced predators; R = rarity.

Scientific name	Common name	Criteria for listing/main threats	Listing advice (reference)	Action Statement prepared (reference)
Engaeus **species**				
Engaeus australis	Lilly Pilly Burrowing Crayfish	(not listed)	SAC (2000a)	No
Engaeus curvisuturus	Curve-tail Burrowing Crayfish	F, R	SAC (2005a)	No
Engaeus mallacoota	Mallacoota Burrowing Crayfish	R	SAC (1993b)	Van Praagh 2003b
Engaeus phyllocercus	Narracan Burrowing Crayfish	A, F, R	SAC (1993c)	Van Praagh 2003a
Engaeus rostrogaleatus	Strzelecki Burrowing Crayfish	F, R	SAC (2000b)	Van Praagh 2003d
Engaeus sternalis	Warragul Burrowing Crayfish	A, R	SAC (1993a)	Morey 1999
Engaeus urostrictus	Dandenong Burrowing Crayfish	R	SAC (2005b)	No
Euastacus **species**				
Euastacus armatus	Murray Spiny Crayfish	RF, S	SAC (2001d)	Van Praagh 2003f
Euastacus bispinosus	Glenelg Spiny Crayfish	S, R (RF & F)	SAC (2001c)	Van Praagh 2003a
Euastacus crassus	Alpine Spiny Crayfish	A, B, S, P, R	SAC (2001f)	Van Praagh 2002
Euastacus diversus	Orbost Spiny Crayfish	F, R	SAC (1992)	Murray 2003
Euastacus kershawi	Gippsland Spiny Crayfish	- (not listed)	SAC (2001e)	No
Euastacus neodiversus	South Gippsland Spiny Crayfish	F, R	SAC (2001a)	Van Praagh 2003e
Gramastacus **species**				
Gramastacus insolitus	Western Swamp Crayfish	A, S, F, R	SAC (2001b)	Van Praagh 2003c

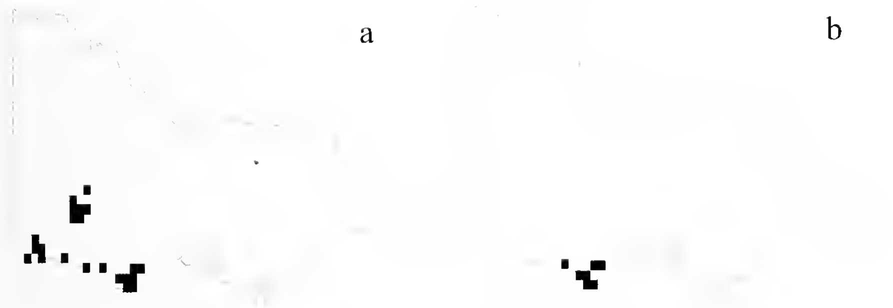
agricultural practices. Forestry activities in highland catchments have been recognised as the main threat to crayfish taxa found in the highlands in Australia (Horwitz 1990b). Removal of trees in lowland catchments has also been identified as a threat to the *Geocharax gracilis* and *Engaeus sericatus* (March and Robson 2005). Morgan (1997) noted that habitat modification by man will contribute to further isolation of crayfish populations in Australia.

To date, most active management directed at conserving crayfish in Victoria has been directed at the larger species, e.g. Murray and Glenelg Spiny Crayfish, (Barker 1990). Following the listing of a number of native crayfish under the *Flora and Fauna Guarantee Act* 1988, the Victorian government addressed the conservation of these species by compiling a series of management strategies or Action Statements (see Table 4) and instituting angling regulations, bag and size limits, restrictions on collection methods and a ban on the taking of berried (carrying eggs or juveniles) female crayfish at any time (Government of Victoria 2002).

Those Victorian crayfish that have a published Flora and Fauna Guarantee (FFG) Action Statement are indicated in Table 4. Action Statements must be compiled for all threatened species and communities as well as potentially threatening processes listed under the FFG Act. Action Statements are basically brief management plans to address the conservation of the species. All but two of the crayfish listed in Victoria now have a published Action Statement but, apart from some limited work on three spiny crayfish in the 1990s that investigated conservation of these crayfish for angling purposes (Barker 1990), there has been little or no monitoring of crayfish populations in the state. The long-term conservation of taxa known to be threatened or declining may be problematic if threatening processes are not addressed.

Threatening processes

In his conservation assessment of Australian crayfish, Horwitz (1995a) noted that '… parastacids in Australia occur in areas where the activities of urbanisation, agriculture, forestry and mining, are liable to have affected their ability to maintain population levels at what they were prior to European invasion.' Given this scenario and the fact that crayfish play a major role



Distribution maps of *Geocharax* species. a. *Geocharax falcata*. b. *Geocharax gracilis*.

Distribution map of *Gramastacus insolitus*.

in aquatic ecosystems (Lorman and Magnuson 1978), a conservation assessment or summary of the conservation of Victorian crayfish taxa is appropriate. Table 4 shows the threatened parastacids recorded in Victoria and the main reasons identified for their listing.

There are a number of threats acting on many Victorian crayfish species (Table 4). Most taxa are rare due to loss of habitat and impacts caused by agricultural development. In addition to the natural predators of crayfish (Kailola *et al.* 1993) e.g. fish, Water Rats *Hydromys chrysogaster*, freshwater tortoises *Chelonia* species and waterbirds, particularly cormorants *Phalacrocorax* species, predation by introduced carnivores e.g. Red Fox *Vulpes vulpes*, has been identified as a threat for the Alpine Spiny Crayfish (Green and Osborne 1981, 1994).

Habitat degradation or destruction, particularly in forested catchments, has been shown to be detrimental to the conservation of crayfish populations in other states (e.g. Tasmania) (Growns 1995) and overseas, but few similar studies on the impacts of forestry operations (or other man-made impacts) have been undertaken on any Victorian crayfish. Edney *et al.* (2002) found that land development and cattle grazing affected the density and occurrence of the 'Swamp Yabby' and suggested that much of the former range of this species is now under agriculture or affected by river regulation. March and Robson (2005) found that two species of burrowing freshwater crayfish (*Engaeus sericatus* and *Geocharax gracilis*) were adversely affected by land uses that degraded soil conditions and vegetation cover. They also found that forested areas had more than twice the densities of freshwater crayfish burrows as in areas of other land uses. In particular their work suggested that cattle grazing may have reduced burrowing crayfish populations in certain streams in south-western Victoria and that fencing to reduce the impact of grazing may be insufficient to ameliorate these effects. Robson (pers. comm. March 2006) suggested that soil compaction arising from stock grazing underlies the lower number of crayfish in non-forest areas of western Victoria. Remnant forest in riparian habitats may therefore act as important refuges for burrowing crayfish in agricultural areas. The limited conservation work done on Australian freshwater crayfish suggests that loss of riparian vegetation (SAC 1996), bank erosion and smothering of instream habitat by increased siltation are the major threats to at least the spiny crayfish and also to some burrowing crayfish species in southern Victoria.

Horwitz (1995a) regarded the following major threatening processes as acting on

various Australian parastacids: agriculture (A) (mainly earth moving and cultivation but including cattle trampling); fire or burning (B); swamp and wetland drainage (W); clearing and loss of native riparian vegetation (including forestry activity) (F); recreational fishing (R); channelisation and other instream alterations such as de-snagging, culverts, weirs and river regulation (S); translocations (mainly for aquaculture) (T) and urbanisation (U). Additional criteria used in this paper for the status of Victorian taxa are rarity or restricted distribution (RRS) and introduced predators (foxes, trout) (P) (see Table 4). There have been no studies in south-eastern Australia looking into the impacts that drought or the effect extensive wildfires have had on crayfish populations. The Glenelg River in south-west Victoria was closed to crayfish fishing between March 2007 and February 2008 due to drought. The conditions produced very low or no river flows, which led to pooling in sections of the river, which in turn led to increased mortality of Glenelg Spiny Crayfish populations. The 2005 Grampians fires resulted in greater access for recreational anglers, thus increasing the risk of over fishing of the Glenelg Spiny Crayfish (DPI 2007).

Environmental perturbations

At least two crayfish species (Murray Spiny Crayfish and Common Yabby) have experienced a number of so-called 'blackwater' episodes in their riverine habitats over the years, mainly in the Murray River and its tributaries (e.g. *Sunday Herald Sun* 1995, McKinnon 1995). The term 'blackwater' refers to flood events that bring stagnant water from the adjacent floodplain into the river, leading to decreased oxygen levels in the water column and resulting in anoxic conditions for instream fauna. Crayfish may then be forced to the surface and many climb out of the water on to stream banks and above-water woody debris, becoming vulnerable to the take by humans and, probably, predation by foxes. McKinnon (1995) estimated that 500 kg of Murray Spiny Crayfish were taken by recreational fishers in 1993 as a result of a blackwater event. McKinnon and Shepheard (1995) recorded over 1000 yabbies and large numbers of shrimp (*Macrobrachium* and *Paratya* sp.) being killed in a 1993 Murray River 'blackwater' incident. McKinnon (1995) also noted that some water control devices (e.g. earthen block banks) used in Murray River forests may actually contribute to blackwater events, and therefore management approaches for the provision of 'environmental flows' need to consider crayfish as well.

Such environmental events have led to temporary closures of the fishery for the species (e.g. in 2000, Fisheries Notice 5/2000). This has also lead to enforcement directed at the illegal take of Murray Spiny Crayfish during these events (*Seymour Telegraph*, 6 September 1995). In the early to mid 1990s, up to 100 infringement notices were issued for the illegal take of Murray Spiny Crayfish at Lake Nagambie (*Seymour Telegraph* 6 September 1995).

The use of pesticides, herbicides and other chemicals may be involved as well, but there is currently little information about these contaminants in the aquatic environment of crayfish.

Concern about the depletion of the Murray Spiny Crayfish was raised by various biologists and conservation and recreational fishing groups in the 1990s (e.g. DSE unpublished information). This led to the closure of the Victorian Murray Spiny Crayfish fishery between 1984 and 1991 (Sharp 1995).

Crayfish conservation – future needs

The basic ecology (distribution, threats etc.) of most Australian freshwater crayfish species is poorly known. This information is required for at least all the restricted-range species if they are to be appropriately managed for the future.

Victoria has a high number of short-range endemic (SRE) crayfish (SAC Database 2007), and various workers believe that human-induced changes in the abundance and geographic ranges of species is actively creating SREs. Invertebrate conservation in Victoria draws upon this pool of species for listing and particular conservation management attention must be paid to these taxa because habitat loss and degradation further worsen their prospects for survival (Harvey 2002). The conservation of

'hotspots' e.g. Tarago Creek Gippsland (Morey and Hollis 1997) where SREs occur, will ensure that the maximum number of these taxa are preserved.

Merrick (1995) identified the most important threat to NSW spiny crayfish as clearing for agriculture (specifically dairying) or forestry with the attendant changes to water quality and eutrophication these activities bring. Agriculture and man-made pollutants also emerged as significant problems for crayfish populations in that state. It can be expected that Victorian waters would be experiencing similar impacts.

Horwitz (1990c) highlighted translocation of crayfish as one of the most crucial processes threatening freshwater crayfish in Australia. This process could lead to the introduction of exotic diseases, displacement of native species, habitat alterations, loss of unique combinations of characteristics by hybridisation, and loss of epibiotic species (those species using crayfish burrows). The potential disease risk for freshwater crayfish in Australia via imported crayfish was recognised almost 100 years ago (Smith 1912). Horwitz (1990c) recommended that more be spent on crayfish disease research, education programs and maintaining bans on imported crayfish. Fortunately, Australia has so far remained free of fungal crayfish disease, but there have been instances of invertebrate parasites attacking some crayfish in Australia (Carroll 1981).

Conclusions

Recommended actions for addressing crayfish conservation in Victoria are as follows (based on Merrick 1995):

1. Baseline biological crayfish surveys:
   Biological research programs should be commenced and followed through to determine baseline biological data, habitat preferences and interactions between native crayfish and introduced salmonids, particularly those crayfish with restricted ranges. There is some recent basic research being done on the Glenelg Spiny Crayfish and some of the Gippsland Spiny Crayfish.
2. Restoration of aquatic habitat:
   No further de-snagging, channelisation or impoundment of headwaters should be permitted. Redundant or unsound impoundments should be removed. Although the development of water resources in terms of large engineering projects has now largely stopped in Victoria, there are still calls for further dam construction and river diversion works that would affect riverine crayfish species.
3. Improve water quality:
   Poor water quality must be addressed, and also potential polluted sites, particularly near or adjacent to species with known small ranges. Urbanisation increases the threat of siltation in streams and should be controlled. Poor water quality remains a problem in most non-forested catchment streams in Victoria.
4. Prevent non-indigenous introductions:
   Prohibit stocking of non-indigenous aquatic species to headwaters, especially where endemic, limited-range crayfish are known to occur. Stocking of trout above natural barriers should cease. Victoria is generally fairly lucky in terms of introduced aquatic species.
5. Restoration of riparian habitats:
   Restoration of damaged or cleared streambanks should commence. There is much scope for restoration of riparian habitats through revegetation and removal of stock access.
6. Manage crayfish fisheries:
   Strict controls on all recreational fisheries for rare and/or threatened species. The recent controls on take of Murray River and Glenelg Spiny Crayfish shows what needs to be done to carefully manage these long-lived angling species.
7. Manage aquaculture industries:
   Further culture of non-indigenous crayfish should be discouraged and a more effective translocation policy should be developed. The illegal introduction of Marron to Victoria indicates that fisheries managers need to be vigilant when looking into the expansion of crayfish aquaculture industry in Victoria.

Mitigation of all the known threats acting on crayfish need to be addressed if Victorian species are to remain as part of the invertebrate fauna in the state. If no active conservation management is undertaken to conserve crayfish habitats and address water

quality issues of these habitats, then it is possible that a number of Victorian crayfish species (especially those with restricted ranges) may be threatened with extinction. Limited understanding of most species' basic biology means we cannot predict with any certainty the long-term conservation of most Victorian crayfish taxa.

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Central Highlands Spiny Crayfish. Photographed by Greg Hollis, DSE Noojee.

Distribution and conservation status of two amphipods in the Dandenong Ranges – *Austrogammarus australis* (Sayce) and *Austrogammarus haasei* (Sayce)

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Abstract

Austrogammarus australis (Sayce) and *A. haasei* (Sayce) (Amphipoda: Paramelitidae) are two amphipod species of conservation significance located in the Dandenong Ranges, Victoria. Original type localities for the species were in and near the Dandenong Ranges. Subsequent surveys have revealed that both species are no longer found at their type localities (most likely due to impacts associated with urbanisation), however they do occur at other sites in the Dandenong Ranges. As the species have a limited distribution in Victoria, they are listed under the *Flora and Fauna Guarantee Act* 1988. The Draft Advisory List of Threatened Invertebrates classifies *A. australis* as 'Vulnerable' and *A. haasei* as 'Critically Endangered'.This paper sumarises results from three surveys for both species with additional notes on changes in their distribution over time. A slight increase in the number of sites at which both species were found was evident from surveys for the species in 1995 and 1999. A survey for the species in 2001 in the Yarra Ranges, an area located close by with similar topography, stream types and vegetation, failed to locate any specimens of either species, highlighting the limited distribution of the species. There have been no taxon-specific surveys for either species across the Dandenong Ranges since 1999. (*The Victorian Naturalist* **124** (4), 2007, 230-235)

Introduction

Background

Amphipods are an ancient crustacean group consisting of small, laterally flattened animals, usually between one and two centimetres long (Williams 1980). A diverse fauna of amphipods inhabits Australian freshwaters, particularly in Tasmania, south-eastern and south-western Australia (Williams and Barnard 1988). They occur in a wide range of permanent and ephemeral habitats, including streams, wetlands, caves and crayfish burrows (Horwitz 1990). Australia has a higher density of freshwater amphipod genera (per km^2 of habitat) than other continents and this is thought to reflect the age of the group, their primary adaptation to permanent and non-tropical freshwater and the large scale changes that have occurred in the nature of the Australian climate over geological time (Williams and Barnard 1988).

The Dandenong Amphipod - Austrogammarus australis *and Sherbrooke Amphipod –* Austrogammarus haasei

A. australis (family Paramelitidae) was originally described as *Gammarus australis* by Sayce in 1901. *A. haasei* (family Parameltitidae) was originally described as *Gammarus haasei* by Sayce in 1902. Both species were placed in a new genus, *Austrogammarus*, erected by Barnard and Karman (1983). *Austrogammarus* is regarded as the most primitive genus of the Australian paramelitids (Williams and Barnard 1988) and now includes seven species; *A. australis, A. haasei, A. smithi, A. saycei, A. spinatus* and *A. multispinatus* and another, *A. telsosetosus*, described by Barnard and Williams (1995). *A. smithi* is found in Tasmania, *A. telsosetosus* is known only from South Australia, while the other species occur to the east of Melbourne in Victoria. Recent findings suggest there are new species and extensions of the range of current species in other parts of Victoria (J Bradbury 1999 pers. comm. May).

Distribution and survey history

The type locality for *A. australis* was given as Dandenong Creek near Bayswater, but other locations where the species was subsequently located were given as: 'a tributary of Monbulk Creek' and 'in a gully

halfway to Sassafras'. The last known record of the species (prior to surveys commencing in 1995, reported in this paper) was in 1911 (Williams and Barnard 1988). The type locality is extremely modified (urban drains) and the species has not been recorded from there since (Williams and Barnard 1988).

On the basis of the lack of new records and the modification to streams around the type locality, the species was classified as 'Presumed Extinct' by Horwitz (1990) and Department of Conservation and Natural Resources (1993). The species was listed under the *Flora and Fauna Guarantee Act* 1988 and an Action Statement was produced recommending the surveying of creeks in the Dandenong Ranges to determine the existence of the species in the area (Department of Conservation and Environment 1991). The Action Statement was later updated (Doeg and Papas 2003) to incorporate findings from these surveys (Doeg *et al.* 1996; Papas *et al.* 1999). The species is presently classified as 'Vulnerable' in the Draft Advisory List of Threatened Invertebrate Fauna (Department of Sustainability and Environment unpubl.).

The type locality for *A. haasei* was given as Monbulk, Vic., 250 m altitude (Williams and Barnard 1988) – suggesting it may have been in Sassafras or Emerald creeks above the town of Monbulk (Doeg *et al.* 1996). The species was listed under the *Flora and Fauna Guarantee Act* 1988 after recommendations made following the 1995 survey (Doeg *et al.* 1996) and is presently classified as 'Critically Endangered' in the Draft Advisory List of Threatened Invertebrate Fauna (Department of Sustainability and Environment unpubl.). An Action Statement was produced recommending the surveying of creeks in the Dandenong Ranges to determine the existence of the species in the area (Doeg and Papas 2004).

Dandenong Ranges survey – 1995

Following recommendations made in the Action Statement (Department of Conservation and Environment 1991), a survey for the Dandenong Amphipod was conducted in June, 1995. Forty-six sites were surveyed in the Dandenong Ranges, east of Melbourne (Doeg *et al.* 1996). Samples were captured with a sweep net of mesh size 300 microns that was swept through organic debris, along stream banks, kicked under rocks and the streambed and scraped against large woody debris. Individual rocks and wood debris were also lifted and examined by eye for the presence of amphipods. *A. australis* was found at nine sites in the upper reaches of Olinda, Dandenong and Monbulk Creeks, and *A. haasei* was found at two sites (Doeg *et al.* 1996) (Fig. 1).

Dandenong Ranges survey – 1999

A second survey for *A. australis* and *A. haasei* was conducted in May and June 1999 (Papas *et al.* 1999). Forty-four sites were sampled using the same method as Doeg *et al.* (1996). A sweep net of mesh 300 μm was used to capture a sample by sweeping the net through organic debris, along stream banks, kicking under rocks and the streambed and scraping large woody debris – 10 m of stream was sampled this way. Material collected was placed in a large sorting tray and all amphipods seen in the sample over a period of 0.5 person hours were collected. Thirty-six of these sites had been sampled during June 1995 and the remainder were new sites thought to be suitable for *A. australis* or *A. haasei*. Some of the 1995 sites were considered too disturbed/impacted to support *A. australis* or *A. haasei* and hence were not included in the 1999 survey (Papas *et al.* 1999). Sites were located throughout the Dandenong Ranges, from all major drainage basins and included sites within the Dandenong National Park, as well as streams from the suburbs of Bayswater, Ferntree Gully, Belgrave, Monbulk, Kallista, Kalorama, Lilydale, Mt Evelyn and Upwey.

In the 1999 survey, *A. australis* was recorded at 17 sites and *A. haasei* at five sites (Fig. 2). All sites containing amphipods were located in the least disturbed areas, with no amphipods found in the more disturbed, lowland sections of streams. Of the 38 sites common to both the 1995 and 1999 surveys, in 1999, *A. australis* was found at 12 sites compared to nine in 1995 and *A. haasei* at five sites compared to two in 1995. This represents

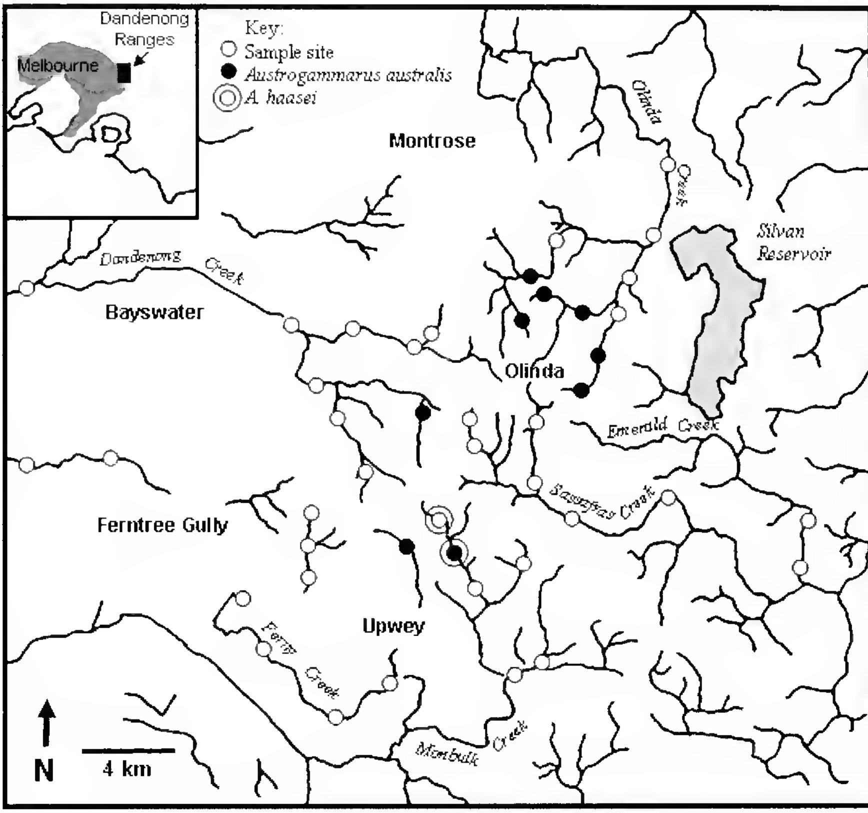

Fig. 1. Map showing the location of sites where *Austrogammarus australis* and *A. haasei* were collected in the 1995 survey (Doeg *et al.* 1996); reproduced and modified with permission from the author.

an apparent increase in the distribution of these species between 1995 and 1999 (Papas *et al.* 1999). Abundances of *A. australis* were generally higher in 1999 (Fig. 3) and there was an increase in abundance of *A. haasei* at some sites in 1999 (Fig. 4).

Subsequent to the 1999 survey, the Action Statement for *A. australis* was updated to include the new distribution and population information (Doeg and Papas 2000; Doeg and Papas 2003). It was recommended that the conservation status of the species be changed to 'Vulnerable' pending the outcome of surveys of other forested areas surrounding the Dandenong Ranges for the presence of *A. australis*, as it was considered that the species might be present in these areas.

Two streams sampled previously by Doeg *et al.* (1996) and Papas *et al.* (1999) were surveyed for *A. australis* in 2002 and 2003 for an honours project that examined the effect of stormwater runoff on the distribution and abundance of the amphipod (Kerr 2004). *A. australis* was present in relatively high abundance at sites in both streams.

Yarra Ranges survey

Following the recommendations in the *A. australis* Action Statement (Doeg and Papas 2000), a survey was subsequently undertaken in the Yarra Ranges, approximately 80 km east of Melbourne, in an area ecologically similar to the Dandenong Ranges. Sites were located in the Yarra Ranges National Park, Melbourne Water closed catchments and State Forest, bounded by the Moorondah Catchment to the north-west, Armstrong Creek Catchment to the north-east and Starvation Creek Catchment to the south.

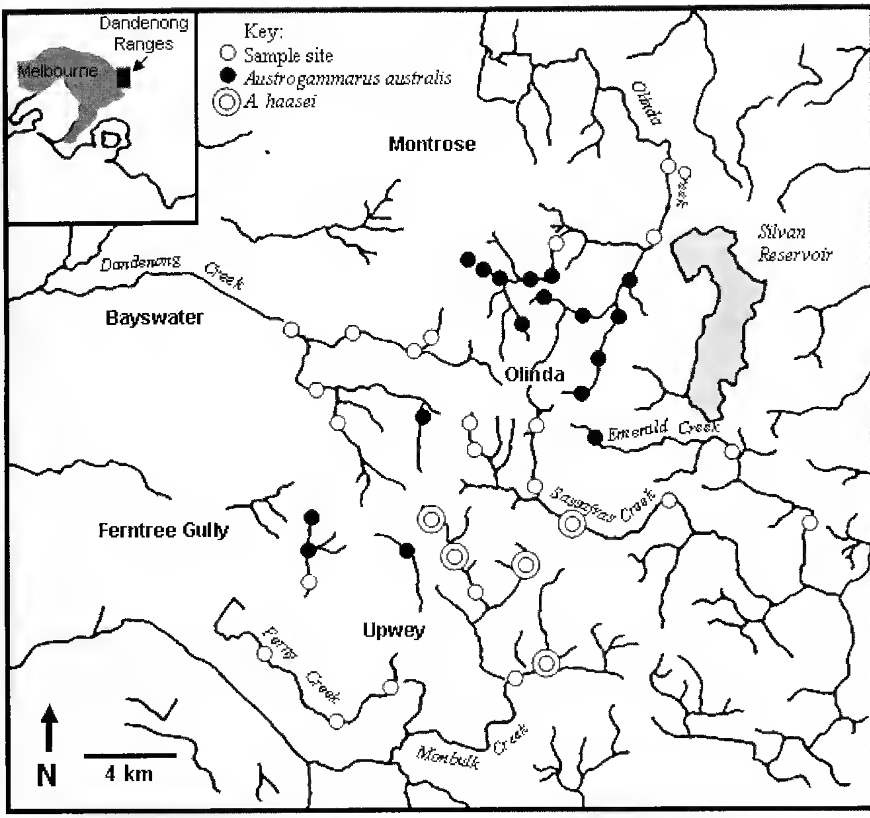

Fig. 2. Map showing the location of sites where *Austrogammarus australis* and *A. haasei* were collected in May and June 1999 (Papas *et al.* 1999); reproduced and modified with permission from the author.

Thirty sites of similar altitude and stream order to those sampled in the Dandenong Ranges in 1995 and 1999 were inspected in this area during May 2002 (Papas and Crowther 2002). Of these sites, nine were deemed suitable for sampling as they approximated stream types in the Dandenong Ranges that contained *A. australis* and/or *A. haasei*. Unsuitable sites were generally those occurring in faster-flowing, larger streams, or streams that were dry. Sites were sampled using the same method as Doeg *et al.* (1996) and Papas *et al.* (1999). No *Austrogammarus* specimens were collected at the nine sample sites. It is unlikely the absence of *Austrogammarus* from these sites is a result of human-induced disturbance as all sites were relatively undisturbed (Papas and Crowther 2002).

Changes in distribution

A. australis is no longer found at its type locality, Bayswater (a Melbourne suburb), most likely due to impacts associated with urbanisation (particularly stormwater runoff) (Walsh 2000; Walsh *et al.* 2004; Kerr 2004). *A. haasei* has also not been recorded at locations near its type locality, Monbulk Creek, again, most likely due to human-induced impacts associated with urbanisation. Note that the exact location of the type locality is unknown.

The known distribution of *A. australis and A. haasei* increased between 1995 and 1999. However, this was not a large area increase and these species remain restricted to the Dandenong Ranges. In the 1999 survey, *A. australis* was recorded from five additional sites and *A. haasei* from three additional sites. Numbers also increased up to ten-fold for both species (Papas *et al.*

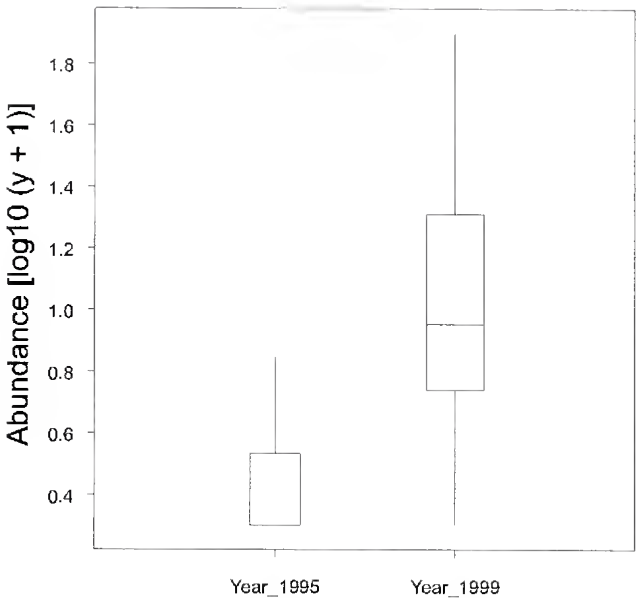

Fig. 3. Box plot eomparing abundance of *Austrogammarus australis* from 1995 and 1999 surveys. Abundance data were transformed using [$\log_{10}$(y+1)]. The middle 50% of data lie within the box, with the median represented by a solid line. Whiskers indieate minimum and maximum values.

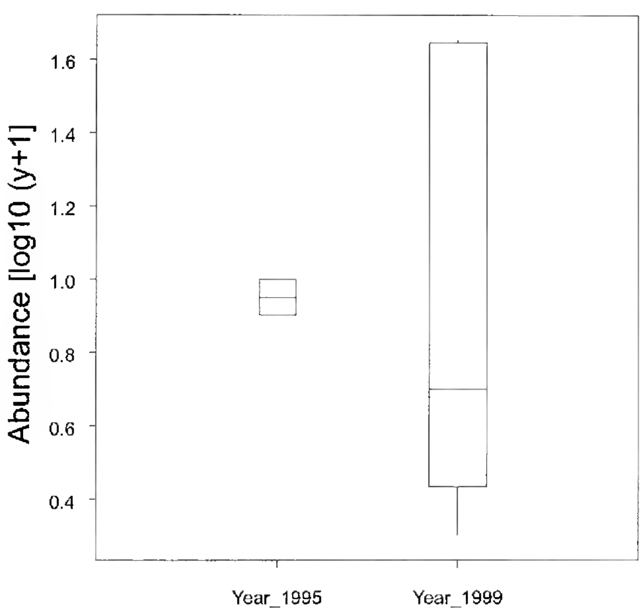

Fig. 4. Box plot eomparing abundance of *Austrogammarus haasei* from 1995 and 1999 surveys. Abundanee data were transformed using [$\log_{10}$(y+1)]. The middle 50% of data lie within the box, with the median represented by a solid line. Whiskers indicate minimum and maximum values.

1999). The reasons for this increase are uncertain; however, some possibilities include natural annual variation in population size, unusually dry conditions between 1996 and 1999 and small variations in the sampling effort and/or strategy. Annual variation in aquatic macroinvertebrate populations has been suggested as an important factor in explaining population changes over time (Resh *et al* 1987; Clements *et al.* 1989). The sampling effort/strategy employed in 1999 may have resulted in the collection of more amphipods as areas of organic debris were targeted; these areas were known to be a favourable habitat for *Austrogammarus* species (J Bradbury 1999 pers. comm. May).

All sites where *A. australis* was located were characterised by undisturbed, riparian zones with native vegetation, and 14 (66%) of these sites were located within national park or other reserves. *A. haasei* was similarly located at sites with riparian zones of relatively undisturbed, native vegetation. Four of these sites (80%) were located within the Dandenong Ranges National Park.

Additional information on the ecological requirements of *A. australis* is provided in Kerr (2004). A new survey in the Dandenong Ranges, targeting sites from the 1999 survey and new sites that may contain either species, is now needed to determine the present distribution of both species.

Acknowledgements
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Austrogammarus australis photographed by Phil Papas

The Eltham Copper Butterfly *Paralucia pyrodiscus lucida* Crosby (Lepidoptera: Lycaenidae): local versus state conservation strategies in Victoria

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Abstract

This paper summarises some aspects of the practical conservation needs of the Eltham Copper Butterfly *Paralucia pyrodiscus lucida,* a small threatened subspecies of butterfly endemic to Victoria, Australia. The butterfly is located in three disjunct regions, separated by hundreds of kilometres across the state as a result of habitat removal and degradation. The three areas of ECB occurrence each have distinct characteristics affecting the needs and intensity of conservation management on the various sites given their urban, regional and rural settings. Butterfly populations have been monitored nearly every year since 1988 with the active support of volunteers, 'Friends of Eltham Copper Butterfly', local councils and government agencies. This information has contributed to a more holistic management regime for the butterfly, and further research aims to elucidate the more intricate details of the butterfly's biology, to continue to refine the current monitoring process across the state of Victoria. (*The Victorian Naturalist* **124** (4), 2007, 236-242)

Introduction

The Eltham Copper Butterfly *Paralucia pyrodiscus lucida* Crosby (ECB) is a Victorian endemic subspecies of the dull copper. In common with many other Australian Lycaenidae, it has declined in range, and has become one of the best-known butterfly taxa in Victoria since a thriving colony was discovered in Eltham, outer Melbourne, in 1987. Before that, it had been believed by many people to have become extinct through site loss caused by urban development since it was described from Greensborough in 1951. ECB was amongst the first invertebrates to be listed under the *Flora and Fauna Guarantee Act* 1988, and has become a powerful ambassador for insect conservation in the state. It is one of few Australian butterflies for which dedicated reserves have been designated for its conservation. The butterfly's biology, outlined by Braby (1990) and Braby *et al.* (1992, 1999), is reasonably well understood. Endersby (1996) also contributed to the biology and behaviour of ECB with detailed field observations of each of its life history stages. The senior author of this paper is currently completing more detailed research on the ECB as part of a higher degree dissertation. Caterpillars feed nocturnally on *Bursaria spinosa*, and are tended by ants of the genus *Notoncus*. They are harboured in the ant subterranean nests by day, around the base of the food plant. ECB is unusual in that populations have been monitored nearly every year since 1988 with the active support and participation of community volunteers, such as the 'Friends of the Eltham Copper', and parallel groups associated with reserves in Castlemaine and Kiata. With their help, counts have been made both of caterpillars and adult butterflies each season.

In this note, we summarise some aspects of the practical conservation needs of the subspecies, and draw attention to (a) differences between the management needs of ECB in three disjunct regions in which the butterfly occurs and (b) differences between the various sites in the Eltham area, for which different agencies have primary management responsibility. Early conservation management plans and status evaluations (Crosby 1987; Vaughan 1988) have continued to form the basis for more recent advances, and enabled progress toward more holistic management. The conservation of the ECB is overseen by the Eltham Copper Butterfly Working Group, which comprises representatives of the various management agencies for the different ECB sites, entomologists, scientists from other relevant disciplines, and the relevant Friends groups.

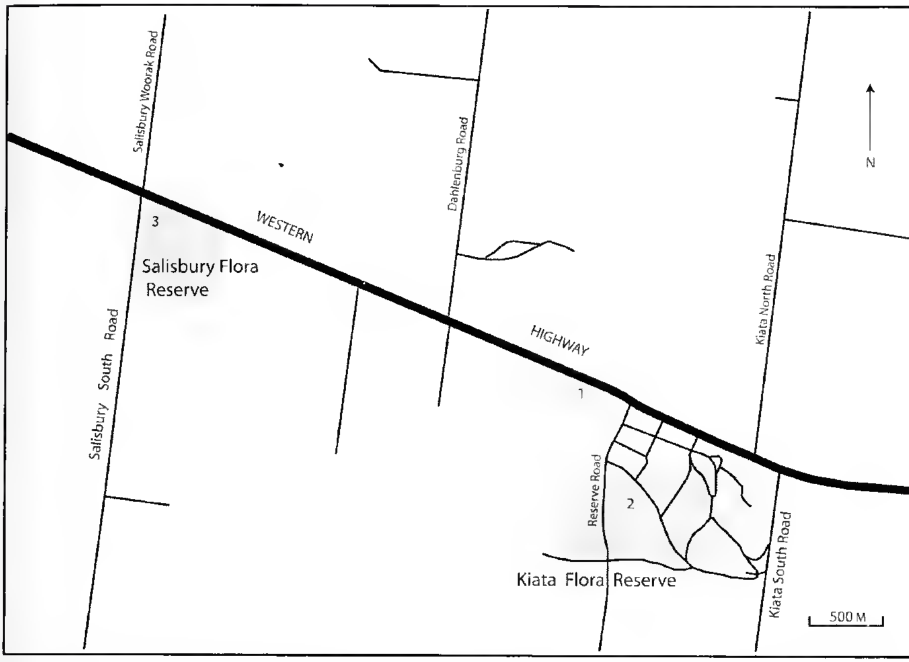

Fig. 1. The Eltham Copper Butterfly locations at Kiata. The Kiata Flora Reserve has two sites, one by the highway (1) and the other in the centre of the reserve (2). There is a small colony at the Salisbury Flora Reserve (3).

Distribution and its conservation implications

The current distribution of the Eltham Copper Butterfly is believed to represent the outcome of considerable range reduction and habitat loss and fragmentation, to leave three highly disjunct areas where the butterfly now occurs (Figs. 1–3). Within each region, the butterfly exhibits characteristic patterns of seasonal development, and within each the distribution is patchy and far less extensive than that of either the larval food plant or the host ant. Phenology and development differs somewhat in the different regions, reflecting climatic differences, and leading to different monitoring needs in each area. At Eltham, a clear univoltine pattern occurs, but with late emergences of adults in some years giving the appearance of a second generation. Adults are present from November to March, occasionally later. Eggs are laid from November, and young caterpillars eclose in December, foraging little during the winter months but resuming regular activity as the weather warms in early spring. In contrast, two distinct generations occur in the Kiata area, where adults of the first generation appear from mid-October, and of the second generation, in February. Phenology at Castlemaine also implies that only one generation may occur. Different species of *Notoncus* host the caterpillars in different parts of the range: *N. capitatus* at Eltham and Castlemaine, and *N. ectatommoides* at Kiata.

The three areas of ECB occurrence each have distinct characteristics affecting the needs and intensity of conservation management on the various sites.

(a) Kiata and Salisbury, in north-western Victoria, harbour populations on several rural sites with patchy *Bursaria*, within a largely pastoral area. Three small colonies of the butterfly are known on large flora reserves (Fig. 1).

(b) Castlemaine. Two peri-urban sites support butterfly colonies, one within the Botanic Gardens, and others, more recently discovered, in Kalimna Park. These sites represent an urban/rural transition, and are surrounded by a mix-

Fig. 2. The Eltham Copper Butterfly sites at Castlemaine are located in the Botanic Gardens and in Kalimna Park (3 and 4). The population at the Botanic Gardens has moved from 1 to 2 since monitoring began.

ture of residential development, natural bushland and grazing lands with ongoing subdivision for urban development (Fig. 2).

(c) Eltham/Greensborough, in outer north eastern Melbourne, where the butterfly occurs on several small (1-3 ha) urban remnant patches, surrounded and isolated by housing. Six major colonies are known, some of them small (Fig. 3). The largest population, at the Western Colony, comprises fewer than 800-1000 individuals.

All sites are nominally protected, some as dedicated reserves, and some by being within reserves with wider conservation responsibility. The sites therehy span the range from large rural sites to small urban ones. These are associated with different threats and different opportunities for the butterfly to disperse and track resources. Thus the larger sites afford opportunity for population movement impossible on the small Eltham sites.

Systematic annual larval and adult counts have been made at all three locations since 1993.These have been conducted by professional entomologists (Van Praagh 1996; Canzano, unpubl. data), Department of Susutainability and Environment, Parks

Victoria, and the Friends groups (Friends of the Eltham Copper Butterfly and Friends of Kalimna Park). These annual counts have provided significant information on distribution and relative abundances of ECB, but the nature, intensity and frequency of counts required to provide reliable quantitative data on ECB in these reserves remains uncertain. The results are influenced by weather conditions and differences in individual observer acuity.

Progress toward effective conservation

As for other butterflies in Victoria, surveys continue to yield new information, both of detail and scale, with recent discoveries of 'new' colonies in Kalimna Park of considerable interest. Only through community awareness can such events be effectively documented and publicised. ECB conservation is broadly overseen by a statewide management group, with representation from all range areas, state and municipal agencies, and independent scientists, and which acts as a clearing house and coordinator of information accruing. Management needs, and the capacity to undertake effective management, differ substantially across the different areas. At Kiata/Salisbury and Castlemaine the potential habitat and sites are sufficiently extensive to facilitate a mosaic of conditions within the area, and for the butterfly populations to track these as they change, so that the butterfly presence and distribution may differ from year to year, or across a longer time scale. Thus, the major colony in the Castlemaine Botanic Gardens has moved from its stronghold in the early 1990s to another site some hundreds of metres away. Such microscale population movements are by no means unusual in butterflies as conditions change, with some species surviving continuously in a suite of habitat patches, only some of which are occupied at any time, on a site and with the population sustained through a series of 'colonisation-extinction-recolonisation'

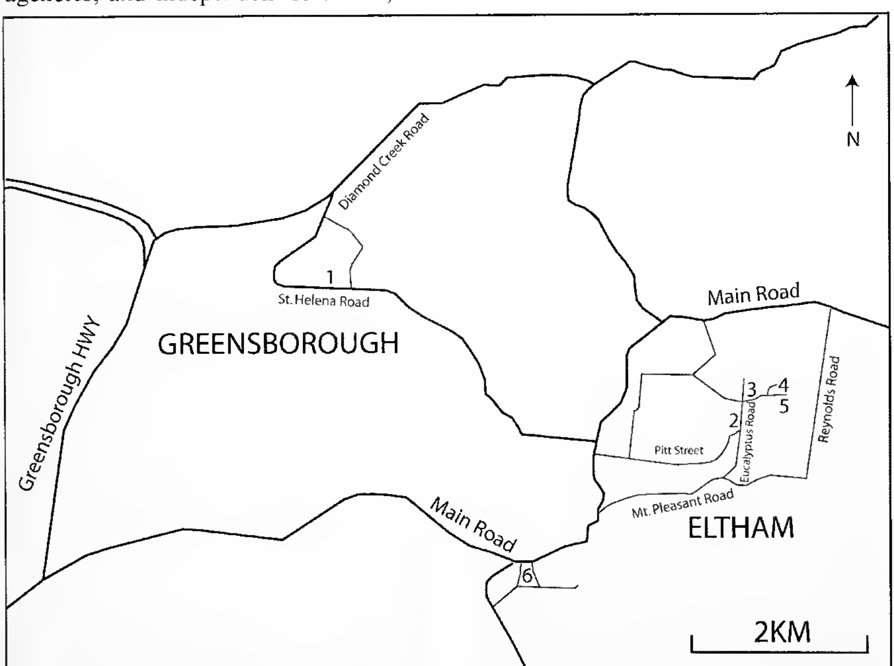

Fig. 3. The Eltham Copper Butterfly sites at Greensborough (1) and Eltham (2-6). The Greensborough site is Yandell's Reserve, while the Eltham sites are the Pauline Toner Reserve (2), the Western colony (3), the Eastern colony (4), the former Yarra Valley Water land (5) and Hohne's Hill (6). The Pitt St Reserve is on the south side of Pitt St adjacent to the Pauline Toner Reserve.

sequences across the landscape: part of the system constituting a possible 'metapopulation' structure. This may be particularly pronounced at Kiata/Salisbury, where the *Bursaria* is very patchy on the sites, and movement between food plant patches (which are also a nectar source for adults) is necessary.

In contrast, this process and population structure is thwarted on small sites. At Eltham, for example, there seems little, if any, chance that butterflies can disperse between the major site-based colonies, because the intervening terrain is highly altered to comprise houses and roads, so that all population processes have to occur (and be sustained) within the confines of single small sites, each of which harbours a discrete population. There is currently little or no opportunity for genetic exchange between those demographic units. Mark-release-recapture studies have not shown exchange of individuals between colonies. However, enhancement of habitat connectivity through carefully planned revegetation of roadside verges and residential properties with the host plant, to allow for 'corridors' for the butterfly, may thereby facilitate movement between habitat patches. Undiscovered colonies may still occur, even in the highly urbanised Eltham location, where additional dedicated reserves for the ECB have been identified over the last five years. These include a block at Pitt Street at the top end of the Pauline Toner Reserve (Yen 2002) and the Yarra Valley Water property that abuts the Eastern Colony. It may be possible to 'link' some of these Eltham reserves with appropriate planting of *Bursaria* in private gardens between them. Management must thus focus on sustaining critical resources in exploitable form in the same small areas, rather than in a wider landscape mosaic, and must therefore counter natural processes (such as succession) to a greater extent than on larger sites.

The underlying ecological differences between the larger and smaller sites dictate in part the nature of threats and the emphasis of alleviative management. Management is necessarily more intensive on small sites, to counter ecological processes and the more proximal anthropogenic threats wrought by edge effects on small areas and by urbanisation on essentially isolated populations. Factors such as runoff, rubbish dumping, weed invasion, vandalism and general human traffic contribute severally and collectively to habitat degradation. Issues of human concern from neighbouring residents also occur. For example, accumulation of fuel on the sites is perceived to increase the risks of wildfire to property. Many of these anthropogenic effects are of minimal importance on the more rural sites, in the context of sustaining critical resources for the butterfly. At Kiata, encroachment of agricultural crops on to ECB habitat, and rabbit/hare grazing on *Bursaria* are concerns. At Castlemaine, activities such as trail-bike riding have caused some concerns at Kalimna Park, in addition to weed invasion and rabbit grazing.

Differences in site scale are linked with threat intensity. Almost inevitably, details of the management needed are site-specific, but the additional implication is that on very small sites, the butterfly is 'conservation dependent' and that continuing management on each site is necessary and must be assured. Long term agency commitment is therefore needed, and can be very difficult to obtain, despite considerable goodwill. Elsewhere, more sporadic management to address particular threats may be a less intensive (i.e. cheaper) but viable option. Again, the interest of individual people is a vital component of ensuring effective monitoring and management of these sites. At all sites, monitoring is a fundamental component of assessing management need by tracking changes as they occur and adapting management accordingly. For example, grazing of *Bursaria* by hares at Kiata led to the erection of fencing to protect critical bushes. Vehicular tracks at Kalimna Park have been blocked or rendered inaccessible to casual visitors.

Continuing management needs around Eltham include:

(a) control of exotic weeds and maintenance or enhancement of *Bursaria*;
(b) maintenance of conditions suitable for *Notoncus*;
(c) prevention of overshading, for example by canopy closure;
(d) removal of fallen debris, as a fuel reduction measure;

(e) minimising inappropriate inputs, such as diverted water runoff, into the reserves;
(f) undertaking any such measures in concert with conservation needed for other significant species on each site;
(g) continuing to foster interest of local people in the conservation process, through volunteer programmes and education.

Other management measures include coppicing of old *Bursaria* to promote fresh growth, enhancement of *Bursaria* by planting (using plants from local seed stocks), and hand removal of weeds (particularly on sites where rare orchids and other plants occur). The last is important on a few sites, on which even moderate human trampling pressure or less sensitive control measures such as herbicide use could prove harmful.

Some such management has been highly experimental, even risky, as with the decision to burn two major butterfly sites (the 'Western Colony' and 'Eastern Colony') at Eltham to 'rejuvenate' them and help reduce canopy closure and weed populations. Such drastic intervention was considered necessary as the major avenue to counter continuing decline in site quality, and in site capacity to host the butterfly (New *et al.* 2000). A 'hot fire' in April 1998, a time when the caterpillars were already present and moderately grown, involved numerous people and fire brigade units, and also involved considerable risk to the butterfly population, but was endorsed on the grounds that should the site become inhospitable that population was in any case doomed. Needs for planning the burn were for it to be as hot as possible (to open canopy and destroy exotic weed seedbanks), as late in the summer as possible (to allow caterpillars maximum feeding time before their food supply was lost), during the day (when caterpillars are underground so not exposed directly to the flames and heat), undertaken only under 'safe' weather conditions, and to extend over much of the site, except for small damped down areas in which caterpillars were particularly abundant. Most caterpillars indeed survived, and the ensuing adult population was not conspicuously diminished.

Timing and intensity of all management is informed by monitoring of the butterfly, both as adults and caterpillars. Intensive monitoring was initiated by Van Praagh (1996), augmented by some student projects on coppicing of *Bursaria spinosa* by the Eltham Copper butterfly (Carroll *et al.* 1998) and observations on larval feeding behaviour as well as germination of *Bursaria spinosa* seeds (O'Sullivan *et al.* 1999). Recent studies on caterpillar mobility, feeding behaviour and frequency, and adult dispersal involving marking individuals and tracking them in their environments (Canzano, unpubl. data) are aiding refinement of the monitoring process, and may help to reduce some of the current uncertainties over interpretations of intergenerational changes in numbers (Johnson 2002) and increase predictive capability. Such recent biological insights will feed directly into a refined plan for conservation of the Eltham Copper, in which the biological differences and opportunities in the different sectors of its range will be treated both individually and in concert for a more holistic overview of management for its future. Without them, or without appreciating the influences of the different sites on the butterfly's potential for survival, management may be severely impoverished through inadequate ecological focus. A prime purpose of the Eltham Copper Butterfly Working Group is to address such issues, and to hone management so that the best possible options are understood and available, both now and for application in the future, perhaps to additional populations should they be discovered or founded deliberately. Whilst these notes have been confined to field populations, a captive breeding programme for the butterfly is also contemplated by the Melbourne Zoo, as an investment in the future of this notable Victorian insect. Further research on the ECB is necessary because of the need for information on the biology and ecology of *Notoncus* ants in relation to the ECB, the genetics of the ECB, and ECB-*Bursaria* interactions to assist its conservation.

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One hundred and One Years Ago

Mr F.G.A. Barnard made some remarks on the larvae and perfect beetles of the Golden Beetle, *Lamprima rutilans*, which he had recently taken from a red gum verandah post at Kew. The post had been in its present position for more than twenty years, and therefore the larvae of the beetle must have got into it since it was placed in its present position. Over twenty larvae and perfect beetles were obtained, the larvae resembling very closely those usually regarded as the larvae of the Cockchafer, *Anoplognathus*, sp. The perfect beetles were all of small size, but very highly coloured.

From *The Victorian Naturalist*, **XXIII** p 116, October 4, 1906

Victoria's butterflies in a national conservation context

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Abstract
Comments are given on the conservation status of Victoria's butterflies, summarising and bringing up-to-date the information previously available in published documents. (*The Victorian Naturalist* **124** (4), 2007, 243-249)

Introduction

The Action Plan for Australian Butterflies (henceforth Butterfly Action Plan, BAP) (Sands and New 2002) is the only published attempt to assemble and assess information on the conservation status and needs of an entire natural group of invertebrates in Australia. It contains dossiers on 220 species or subspecies flagged for some conservation interest in Australia, and reviews all species and subspecies occurring in the region. The information was derived from published sources and from wide consultation, including workshops in all States and Territories, which were attended by many of the country's most experienced and knowledgable butterfly enthusiasts. This broad treatment allows us to consider the current status of the butterflies flagged for conservation significance in Victoria, some listed under the Flora and Fauna Guarantee Act 1988, in the wider national context. We indicate more recent information on a few taxa, and note also the account by Field (1995) in which he commented on 21 Victorian taxa that he believed to have declined in the state over the previous century.

The butterflies

The 12 taxa reported in BAP as threatened in Victoria (Table 1) are all members of major endemic butterfly radiations in Australia (New 1999), within the Hesperiidae (4 taxa), Nymphalidae (1) and Lycaenidae (7). Several of these are distributed far more widely in Australia, and their conservation interest in Victoria is essentially state-based. The Small Ant-blue *Acrodipsas myrmecophila*, for example, occurs widely elsewhere but is known currently from only one isolated colony in Victoria, at Mount Piper, Broadford (Jelinek 1995; New and Britton 1997). This population appears to be separated from any other by at least several hundred kilometres, and merits conservation as an isolated outlier of the species in a region where other colonies are known to have become extinct due to loss of habitat. This situation differs markedly from a 'politically isolated' population simply marking the edge of a large continuous range by extending narrowly into the state.

It is important to note that these 12 taxa were categorised on the basis of definable threats, rather than simply for their rarity, even though rarity may be a predisposition to threat in some cases. Other taxa, such as *Oreixenica latialis theddora*, endemic to the Mount Buffalo plateau, were reported as 'Lower Risk (Near threatened)', because tangible threats were not easily definable. This butterfly is abundant and widespread on Buffalo, itself a national park in which butterfly management (if needed) could be undertaken within a secure habitat. However, for any such isolated species, stochastic events such as bushfires may be devastating, but their effects very difficult to predict. Other than fire (with the outcomes of recent fire on the plateau not yet known) the main possible threat to *O. l. theddora* may result from contraction of the alpine area through global warming. Contraction of range is an important potential indicator for such changes on the plateau, but it is indeed difficult to formulate constructive conservation management for such an eventuality for species that appear already to be on the 'extreme edge' of their potential range.

Table 1. Butterflies in Victoria ranked as threatened at either national or state level in BAP

Taxon	Conservation status	FFG listed
HESPERIIDAE		
Hesperilla flavescens flavescens	Vulnerable	Yes
H. idothea clara	Vulnerable in South Australia	No
Telicota eurychlora	Threatened in Victoria Vulnerable in Queensland	Yes
Trapezites phigalia	Vulnerable in South Australia	No
NYMPHALIDAE		
Heteronympha cordace wilsoni	Critically endangered	Yes
LYCAENIDAE		
Acrodipsas brisbanensis cyrilus	Vulnerable	Yes
A. myrmecophila	Endangered in Victoria	Yes
Candalides noelkeri	Endangered	Yes
Ogyris idmo halmaturia	Endangered	Yes
O. otanes	Endangered in Victoria	Yes
O. subterrestris subterrestris	Vulnerable in South Australia and Victoria	Yes
Paralucia pyrodiscus lucida	Vulnerable	Yes

Table 2. Butterflies recorded in Victoria but which are regarded as of 'Lower risk' (LR), 'Data deficient' (DD), or for which main conservation concerns are elsewhere. Range states/territories are given by initial letters.

Taxon	Range	Conservation concern	FF listed
HESPERIIDAE			
Hesperilla chrysotricha leucosia	SA,V	LR (SA)	No
Trapezites eliena	Q, NSW, ACT, SA,V	LR (SA)	No
T. luteus luteus	SA, V	LR (SA)	Yes
T. symmomus soma	SA, V	LR (SA)	No
NYMPHALIDAE			
Oreixenica kershawi kanunda	SA, V	LR; Vulnerable in SA	No
O. latialis theddora	V	LR	Yes
O. lathoniella herceus	NSW, ACT, SA, V	DD (SA)	No
LYCAENIDAE			
Acrodipsas brisbanensis brisbanensis	WA, Q, NSW, ACT, V	DD (WA)	Yes (as species)
Hypochrysops ignitus ignitus	Q, NSW, SA, V	LR (SA,V)	Yes
Jalmenus icilius	WA, Q, NSW, ACT, SA,V	LR (V)	Yes
Nacaduba biocellata biocellata	WA,NT,Q,T,NSW,SA,V	DD (T)	No
Pseudalmenus chlorinda zephyrus	T, NSW, ACT, V	LR (T)	No
Theclinesthes albocincta	WA, NT, Q, NSW, SA,V	DD (Q)	Yes

This, and other 'lower risk' or 'data deficient' taxa (the latter being those for which available information is insufficient to formulate sound inference) are noted in Table 2: most are of little current concern in Victoria. All are members of the same taxonomic groups represented in Table 1.

In this note, we comment on several of the threatened species in Victoria, to exemplify the range of concerns arising from BAP, and to note some advances from that time. One of the taxa, the Eltham Copper *Paralucia pyrodiscus lucida* (a subspecies endemic to Victoria) is treated separately in this issue of *The Victorian Naturalist* (Canzano *et al.*, this issue). The Eltham

Copper is an important flagship for invertebrate conservation in the state.

The threat categories noted in Table 1 are 'critically endangered' (most serious), 'endangered', and 'vulnerable'.

Notes on selected taxa

Critically endangered

Heteronympha cordace wilsoni. This narrowly distributed satyrine is the only Victorian butterfly given this status. It is known only from the far south west of Victoria (around the mouth of the Glenelg River) and a small abutting area of far south-eastern South Australia, and at the time of BAP had not been recorded for some time – the most recent records were in 1980 (Victoria) and 1976 (South Australia), and there were fears that it might have become extinct as a consequence of continued habitat degradation in the area. Caterpillars feed on species of *Carex*, and the major factor in the butterfly decline has been drainage and clearing of the wetlands in which the host plant grows, with subsequent further degradation through overgrazing by cattle. This has led to some former sites being unlikely to host the butterfly in the future. Historically-extant populations were generally small, localised, and presumed to be closed, as adult butterflies appeared to disperse little, so that small dedicated reserves may be the key for conservation. The major recommendation of BAP was to instigate surveys throughout its historical range to determine whether *H. c. wilsoni* still exists, as a prelude to providing effective protection for any populations found.

A small colony was discovered in South Australia in 2004-2005, with its presence described as 'precarious' (Grund 2006) and reported formally by Haywood and Natt (2006). Grund (2006) noted also that the butterfly has reappeared within the last two seasons at formerly occupied *Carex* marsh sites, in both southeastern South Australia and western Victoria. Further investigations may lead to downgrading of status to 'endangered'.

Endangered

Candalides noelkeri, known from two small saline sites in inland western Victoria, is (as noted above) significant as the state's only endemic butterfly species. Before its recent formal description (Braby and Douglas 2004), it was referred to (e.g. in BAP) as *Candalides heathi* ssp. 'Wyn Wyn' or 'Wimmera form'. The two known breeding sites are about 3 km apart, and they occupy collectively about 3 ha. Both sites are now conservation reserves: Lake Wyn Wyn Wildlife Reserve is managed by Trust for Nature, Victoria, and Oliver's Lake Flora Reserve by Parks Victoria and private landowners. Caterpillars of *C. noelkeri* feed only on *Myoporum parvifolium* in small areas of floodplains between saline lakes and adjacent woodland.

Major threats are site invasions by *Melaleuca halmaturorum*, creating dense shade and reducing the habitat occupied by *Myoporum* and (at Wyn Wyn) also by Horehound *Marrubium vulgare*. Although Sands and New (2002) suggested that rising salt levels pose a further threat, this was not considered likely by Braby and Douglas (2004). However, with such narrow distribution, and additional searches not yet revealing any further populations, intensive site management may be needed to conserve the butterfly.

Ogyris idmo halmaturia (possibly a distinct species, rather than a subspecies) is known from South Australia and Victoria. Other than a sighting in the Grampians in 1970 (Douglas 1995), it has not been seen in the State since 1945, with the only known colony (near Kiata, Little Desert) lost by clearing vegetation for agriculture. It was rediscovered in South Australia only in the mid 1990s (Hunt *et al.* 1998), with three colonies reported. It is Endangered in both range states. Surveys are needed to attempt to confirm whether the butterfly still exists in Victoria.

The caterpillars associate with *Camponotus* ants nesting around the base of eucalypts and other trees. However, unlike most other species of *Ogyris*, these larvae may be entirely predatory, and feed on the ant brood rather than on mistletoes, which are generally absent from trees supporting *Camponotus* nests.

Ogyris otanes. This species has a wider geographical range than most taxa noted here, but the South Australia/Victoria populations constitute a distinct 'form' (Dunn and Dunn 1991; Williams and Hay 2001).

In South Australia, it occurs sporadically in the southern temperate mainland areas, mainly in mallee country where the larval food plant *Choretrum glomeratum* grows, and on Kangaroo Island. It has become rare on the mainland due to vegetation clearing. Although apparently secure on Kangaroo Island, it is Vulnerable on the mainland (Grund 2002).

In Victoria, the food plant is *Choretrum spicatum* and, as elsewhere, the caterpillars associate with *Camponotus* ants. Its persistence in Victoria needs confirmation. The main known population (in the Big Desert) may be extinct, and butterflies have not been seen there since 1977. The few other Victorian records are also from the Big Desert region. Increased targeted surveys, perhaps focusing on the scattered patches of *C. spicatum* (as recommended by Douglas 1995), are needed to confirm its presence.

Acrodipsas brisbanensis cyrilus is another lycaenid known only from South Australia and Victoria. Its separation from the nominate subspecies is regarded as questionable by some workers, because of substantial individual variation in the adult butterflies. The few populations regarded as this subspecies occur in remnant woodland/forest patches, some close to Melbourne, but very little is known of its developmental biology. As with *A. myrmecophila*, caterpillars associate with *Papyrius* ants, and live within the nests. Many of the records are of hilltopping adults, and their breeding sites remain unknown.

The single known site in south-eastern South Australia is said to be secure. However, the butterfly has not been seen there since its original discovery, and burns of nearby areas have created some uncertainty over its continued existence (Grund 2004). The major Victorian population is within the Little Desert NP (Douglas 1995). An apparently well-established colony there may afford the best opportunity for study to clarify basic biology. Several former colonies of the butterfly elsewhere have been lost, including some close to Melbourne that have succumbed to urban development (New and Sands 2002).

Acrodipsas myrmecophila was noted earlier. It was regarded in BAP as secure over most of its extensive Australian range, but Data Deficient in the Northern Territory and Endangered in Victoria. It is thus of considerable state significance. Caterpillars live within nests of *Papyrius* ants ('coconut ants') and feed on the ant brood.

Most knowledge of the species in Victoria is derived from a now extinct colony at Ocean Grove and more recently from a population at Mount Piper. The latter led to some innovative suggestions for management, such as the use of wooden trap nests to enhance ant colonies and for use as possible translocation units for the butterfly (Britton 1997). In the future, it may be practicable to use knowledge of the butterfly from studies elsewhere in its range to improve conservation management in Victoria.

Vulnerable

Three butterfly taxa are listed as Vulnerable in Victoria in BAP.

Hesperilla flavescens flavescens is one of two subspecies of an endemic skipper, itself a member of a species complex. In common with the South Australian *H. f. flavia*, it is associated with small wetland sites supporting the larval food plant sedge *Gahnia filum*. The subspecies name is applied to the distinctive clinal 'yellow form' characteristic of a few populations near Melbourne, with the common epithet of 'Altona skipper' emphasising this localised distribution over a few swamps from Point Cook to the Altona region. Threats have broadly reflected urbanisation (New and Sands 2002), and a variety of conservation needs were summarised by Crosby (1990) and in BAP. Recent management at two key localities, Point Cook and Truganina Swamp, has included plantings of *Gahnia* to extend the range and counter the slow natural recruitment of the host plant population (Savage 2002).

Ogyris subterrestris subterrestris has historically been confused with *O. idmo*, and is known from Victoria, New South Wales (a single record near Broken Hill) and South Australia (three sites). Pending its recent description (Field 1999) it was listed in Victoria as '*Ogyris* sp. aff. *idmo*'. A second subspecies occurs in Western Australia. In Victoria it is restricted to the far north-west, around Mildura and in the Hattah-Kulkyne and Murray-Sunset NPs,

where it is associated with *Camponotus* ants. It appears always to have been scarce, with probable declines due to vegetation clearing and overgrazing by sheep (Douglas 1995), as well as wider general disturbance which might lead to loss of *Camponotus*. A broad current biological knowledge could form the foundation for constructive conservation based on restriction of vegetation clearing around known sites and further targeted searches in the north-west.

Paralucia pyrodiscus lucida occurs in three widely separated areas of Victoria, most famously around Eltham in outer north-eastern Melbourne, where the small isolated occupied sites are important urban remnants demanding continuing management to retain their suitability. The Eltham Copper has received more dedicated conservation attention than any other butterfly in Victoria (see Canzano *et al.* this issue).

The taxa listed in Table 2 are predominantly those whose wide range is associated with greater conservation importance elsewhere than in Victoria. Only *Oreixenica l. theddora* , noted earlier, is restricted to the state. Two others are noted as 'Lower Risk, near threatened' for Victoria, and are noted briefly below.

Hypochrysops ignitus ignitus. The 'Lower risk' status evaluation is shared with South Australia, but this butterfly is one of the most widely distributed *Hypochrysops* in Australia. Substantial habitat loss has occurred in South Australia and Victoria, leading to concerns in those states, with evaluations up to 'Vulnerable' (Grund 2005). Further surveys are needed in Victoria to ensure that sufficient populations are included in major reserves such as national parks, and to secure these adequately against disturbance.

Jalmenus icilius. This species is very widely distributed in many open woodland and mallee communities but is extremely scarce in Victoria, where it occurs only as putative remnant populations following extensive clearing of natural vegetation for agriculture. Douglas (1995) knew of only five Victorian localities, and ranked *J. icilius* as 'Endangered'. The major initial need is for more extensive surveys and, in particular, to confirm (and, if found, secure) its existence in the Grampians NP.

Discussion

Evaluating the status of butterflies for conservation need is never easy, except in clearcut cases of single (or few) populations clearly threatened by tangible impositions whose abatement can be a focus for management. Such management is usually based also on sound biological understanding of the focal taxa, so that good basic research is often a precursor to effective conservation. However, because major gaps in knowledge persist, practical conservation must commonly proceed in its absence. In this case the focus is necessarily often to conserve the habitat or site at which a species occurs as a basis for pursuing more detailed management, should this be needed.

Several of the 18 Victorian butterflies listed under the *Flora and Fauna Guarantee Act* (at July 2006) were not considered threatened in BAP; and no Victorian butterflies are listed for national protection under the Federal Endangered Species and Biodiversity Protection Act 1999. The anomalous Victorian taxa are the skippers *Antipodia atralba* and *Telicota eurychlora*, the satyrine *Hypocysta adiante*, and the lycaenids *Ogyris genoveva araxes* and *Theclinesthes albocincta*. Field (1995) listed several other taxa, but all of those appear to be secure in reserves, or locally well-established.

Antipodia atralba is regarded as naturally rare, but with current distribution suggesting decline (Douglas 1993). It can become common following vegetation regrowth after fires (Braby 2000). *Telicota eurychlora* is known from only one location in Victoria, at the mouth of the Thurra River, where the small isolated population is secure in the Croajingolong NP. *Hypocysta adiante* is common along much of the east coast of Australia, but probably only a 'political vagrant' in Victoria, where it has been reported only from a single record at Cudgewa, close to the northern State border: it has not been confirmed as a breeding resident in Victoria. *Ogyris genoveva araxes* has apparently diminished in abundance and some populations have been lost. However, BAP workshop participants implied that the butterfly is not threatened at present, not least because a number of populations are in reserves. Finally, *T.*

albocincta has been ranked as 'Vulnerable' (Douglas 1995), but conservation may be needed only over parts of the species' extensive range. In Victoria, some key habitats may have succumbed to vegetation clearing and subsequent sheep and rabbit grazing of foodplants.

Other species worthy of note include the skipper *Netrocoryne repanda repanda*, which until recently was known in Victoria from only one specimen. It is now known to be breeding in the Buchan Caves reserve. A distinct form of the lycaenid *Candalides absimilis* is restricted to the south-east corner of Australia, with breeding colonies in the Mitchell River NP and at Buchan. Both these taxa have been found on remnant vegetation and street trees at Buchan.

'Conservation status' is a dynamic condition, often very difficult to confirm and justify, and the criteria used by various workers and in different contexts vary considerably; it can also change rapidly with human influences in the environment. Many other butterflies in Victoria could easily become threatened. For example, recent widespread fires may have caused losses of isolated butterfly populations in many parts of Victoria, but the extent of these effects is at present unknown. The above appraisal is thus open to severe revision. Any such evaluations of threat should be subject to periodical critical review, in order to facilitate adaptive management and the most rational allocation of priority. Butterflies are unusual amongst invertebrates in that such review is indeed possible.

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The conservation of the Giant Gippsland Earthworm *Megascolides australis* in relation to its distribution in the landscape

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Abstract

It is difficult to identify the main factors that determine the distribution of the Giant Gippsland Earthworm because of the completely subterranean nature of this species. Past emphasis has involved research on soil factors (such as texture and chemical composition) and topography (slope, aspect, proximity to water). More recent research indicates that its distribution results from a combination of many interrelated factors, most importantly, underground hydrological processes. The pre-European settlement environment for the Giant Gippsland Earthworm was predominantly tall wet forest, but it has survived in pockets of exotic pastures and riparian zones. However, some of the revegetation programmes established to address degraded habitat may ultimately be detrimental to surviving populations of the Giant Gippsland Earthworm. (*The Victorian Naturalist*, **124** (4), 2007, 249-253)

Introduction

The Giant Gippsland Earthworm *Megascolides australis* is listed as 'Vulnerable' under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* and 'Threatened' under the Victorian *Flora and Fauna Guarantee Act 1988*. The development of conservation strategies for this species has not been straightforward because of its totally subterranean nature and the difficulty involved in identifying its habitat without detailed surveys that involve destruction of habitat and death of individual worms.

The subterranean nature of *M. australis* and its presence in landscapes without native vegetation often results in its neglect from consideration in planning applications. Conservation decisions in the terrestrial environment are based very much on the presence of vegetation and its condition (relative to its supposed condition at the time of European settlement). Vegetation is used as a surrogate for many threatened species, and improvement in vegetation condition is often viewed as part of the solution required to conserve threatened species. Problems arise when a threatened species such as *M. australis* is not necessarily associated with native vegetation.

Distribution of the Giant Gippsland Earthworm in relation to altered landscape

Megascolides australis has co-existed with agricultural land use since European settlement of South Gippsland in the 1870s, and has survived major changes to its habitat, mostly associated with agricultural development and expansion. However, the overall effects of these habitat changes on *M. australis* populations and their distribution are not clearly understood. *Megascolides australis* is confined almost entirely to privately owned agricultural land with only small pockets of remnant vegetation remaining along some stream banks, gullies and road sides. Mt Worth State Park is the only area within the species' range that has remnant vegetation and *M. australis*; it is located at the eastern extreme of the range of this species.

The reduction in *M. australis* range has generally been attributed to post-European settlement tree clearing and subsequent agriculture practices. Within this present agricultural landscape, *M. australis* is generally associated with stream banks, wet gullies/soaks, and south facing hillslopes with terracettes. Its distribution appears to be primarily correlated with hydrological conditions that remain to be identified.

There is no historical information available on the distribution of *M. australis* at the time of European settlement. It is thought that before European settlement, the area was covered by wet forest with continuous canopy cover, but old forests were probably dominated by fewer larger trees with a more open understorey. The ground layer was more grassy and with more logs and coarse woody debris. The thick regrowth often associated with this type of wet forest was due to fires, but the area did not experience many fires, and most of the forest was thought to be mature. The lower slopes were dominated by *Eucalyptus strzeleckii* and higher slopes probably by *Eucalyptus regnans* (David Cameron and Josh Dorrough, pers. comm. 2004).

Since the 1870s, extensive forest clearing, introduction of grazing animals and the maintenance of a more-or-less continuous ground cover of sown pasture has greatly altered the surface and sub-surface hydrology. The effects of initial vegetation clearance on soil habitat would have been pronounced in the upper soil horizon where increased exposure after tree removal would have resulted in decreased moisture levels. This may have resulted in fragmentation of *M. australis* populations and local extinctions. However, the deeper soil horizon primarily occupied by *M. australis* would have been somewhat buffered from the initial changes in soil microclimate and may have experienced increase in available moisture due to the absence of large trees transpiring and removing soil moisture. *Megascolides australis* habitat would also have been reduced by the loss of topsoil over time through increased runoff (Van Praagh *et al.* 2004, 2005). Giant Gippsland Earthworms are non-selective, geophagous feeders, relying on organic matter, bacteria and fungi digested from soil passed through the gut (Van Praagh 1994). This generalised diet and their depth in the soil profile may have allowed them to cope with the change from forest to permanent pasture and in time, adapt to the changed conditions.

Past research on the factors determining distribution of the Giant Gippsland Earthworm has emphasised soil and topographical factors (slope, proximity to water) (Van Praagh *et al.* 1989; Van Praagh 1992). More recently, the distribution of *M. australis* was assessed at two locations, Jumbunna at the southern end of its distribution and Ellinbank towards the northern end of its distribution (Van Praagh *et al.* 2004, 2005). *Megascolides australis* was found in four distinct habitats at Jumbunna: minor creek and drainage lines, flat to gentle sloping alluvial terraces above present flood levels, steep south facing hillslopes with terracettes and colluvial footslopes without terracettes. The landscape features at Jumbunna that are thought to influence *M. australis* distribution are the nature and depth of the soil, slope, micro-topography and aspect of the steep hillslopes, in addition to site soil and surface hydrology. *Megascolides australis* was found in only one main habitat at Ellinbank, the lower slopes and colluvial and alluvial terrain adjacent to the stream channels and just above the level reached by moderate flooding. This is in contrast to the four habitats for *M. australis* at Jumbunna and may be due to differences in geomorphology between the two sites. The slopes at Ellinbank are morphologically simple and lack the distinct segmentation observed at Jumbunna in the steeper, higher terrain of the Strzelecki Ranges. There are no major differences in slope form between the upper and lower slopes in the Ellinbank study area, and the ridge crests are broad and gently rounded. The slopes also lack the distinctive tread and riser terracing ('sheep tracks'), that is a characteristic of the steeper terrain developed on sedimentary rocks, and soils were more coherent and with lower moisture content than the terraced features. This morphologically simpler landscape appears to provide fewer areas of suitable *M. australis* habitat with the appropriate hydrological parameters. Whether these features are characteristic of the broader geomorphology of the basalt-derived soil landscapes in the north of the species' range requires further investigation. This comparison illustrates the complexity of factors that determine distribution of *M. australis*.

Current thoughts on revegetation and the Giant Gippsland Earthworm

Revegetation programs are widely advocated for a variety of reasons including to control for soil erosion, to reduce water-

logging and to protect water quality of streams, and to provide shade and shelter for stock (Thompson *et al.* 2003; G. Trease pers.com. 2005). Increasing the nature conservation value of an area may also be included, and for the past 10 years revegetation of *M. australis* habitat has been one of the key recommendations for the conservation of *M. australis* on private land (e.g. Van Praagh 1991; Taylor *et al.* 1997). Plantings are used in a variety of situations including riparian strips, gullies, landslips, windbreaks and as linkages between remnant vegetation. The current recommendations for revegetation in the south Gippsland region include approximately 2000 plants per ha with a species composition of 15-25% trees, 40% mid-storey and the remainder understorey and grasses. However, the proportion of tree species in the area has been as high as 40% (G. Trease pers. com. 2005).

Results of research into distribution of *M. australis* at Mt Worth State Park, the only area within the species' range to support remnant vegetation, first brought attention to the possibility that dense revegetation of habitat occupied by *M. australis* may not necessarily be of benefit to the species and may indeed be harmful (Van Praagh and Hinkley 1999). During this survey work, populations of *M. australis* were found to occur predominantly in open pastured areas within the Park and on clay management vehicle tracks, and distribution was limited to the edges of more densely vegetated areas.

It is possible that major alteration to soil hydrology in the current landscape, such as extensive tree planting, may pose a threat to populations of *M. australis*. These plantings may impact on the sub-surface area available for *M. australis* habitat by filling potential occupation space with tree roots and woody debris. There is also the likely impact on the water table, whereby increased transpiration rates will lower water tables, leading to drying of soils in potential worm habitat on the lower slopes, colluvial slopes and floodplains, thereby decreasing suitable habitat for *M. australis*. Whilst not all factors influencing the distribution of *M. australis* are known, one of the most important is related to soil hydrological factors. Active populations are always found in moist soils and the burrows are very wet, often with a significant amount of free water flow in them. For example, where *M. australis* occurs on the steep mid to lower slopes of south facing steeper hillslopes, they are usually associated with areas of groundwater seepage zones that can be identified by the presence of terracettes. The presence of terracettes indicate that the land surface is wetter than the surrounding area, which may be important in sustaining conditions required for *M. australis* survival. The terracettes provide increased soil moisture through temporary pondage during run-off, thus allowing retention and recharge of soil moisture.

Future research needs for the conservation of *M. australis*

At present the effect of revegetation on *M. australis* habitats is unknown and remains speculative. However, the absence of *M. australis* from heavily vegetated sites at Jumbunna (Van Praagh *et al.* 2004), Ellinbank Research Station (Van Praagh *et al.* 2005) and their presence in pasture adjacent to native forest and clay service vehicle tracks at Mt Worth State Park (Van Praagh and Hinkley 1999) suggest that recommendations to revegetate *M. australis* habitat for its conservation need reassessing. In a recent report on Best Management Practices for riparian habitats in Gippsland dairy regions, Thompson *et al.* (2003) found that their suggested index of riparian condition indicated that an excellent condition score required vegetation 30 metres wide on either side of a stream. Whilst the broader benefits of revegetation of riparian zones are acknowledged, the effects of dense replanting of areas occupied by *M. australis* require investigation. Very few stream areas in South Gippsland currently have 30 metres of vegetation on either side, and if revegetation projects aim to recreate buffers of this width, then the effects on *M. australis* have to be considered. Despite the preliminary nature of these findings, given the scale of revegetation in the region, and in particular the often very dense planting of riparian *M. australis* habitat, revegetation may represent one of the most important potential impacts on populations of *M. australis*.

With the increasing rate of land use changes within the distributional range of the Giant Gippsland Earthworm, there is an urgent need to address this situation. Two immediate research requirements to assist its conservation can be identified. First, a program to determine the impacts of revegetation on factors such as soil moisture, hydrological patterns and water table levels, and how these might impact on populations of *M. australis*. This is not a criticism of revegetation as a form of habitat restoration, but in the case of *M. australis* the appropriate levels and methods of revegetation need to be assessed. Second, the inappropriate use of native vegetation cover as a surrogate for habitat for threatened species such as *M. australis* needs to be addressed. Research is required to identify high priority Giant Gippsland Earthworm habitat using non-destructive techniques, such as digital elevation modelling, followed by ground truthing. Without these, the land use changes in South Gippsland may result in a rapid destruction of the remaining *M. australis* populations.

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Egg capsule of Giant Gippsland Earthworm *Megascolides australis*. Photograph supplied by Alan L Yen

Treeless habitat of the Giant Gippsland Earthworm: south facing terraced hillslope and creek banks above an active flood plain. Photograph by Beverley van Praagh.

Giant Gippsland Earthworm *Megascolides australis*, in situ. Photograph by Beverley van Praagh.

The Golden Sun-moth *Synemon plana* (Castniidae) on Victoria's remnant southern native grasslands

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Abstract
The complex adult biology of the Golden Sun-moth *Synemon plana* Walker is outlined, and the difficulties of appraising its conservation status and needs in Victoria are discussed. (*The Victorian Naturalist* **124** (4), 2007, 254-257)

Introduction

The day-flying Golden Sun-moth *Synemon plana* Walker now occurs on a number of remnant patches of native grassland in south-eastern Australia, with a range encompassing parts of Victoria, New South Wales (NSW) and the Australian Capital Territory (ACT). It has become an important invertebrate flagship for this endangered ecosystem. *S. plana* is a member of a distinctive endemic genus of Castniidae, many species of which are scarce and highly localised (Douglas 1993). Several studies in Victoria have been important in elucidating its biology and conservation needs. Genetic studies (Clarke and O'Dwyer 2000; Clarke 2000) imply that Victorian populations may be rather distinct from the remainder of the species.

Biology and incidence

Synemon plana is associated with grassland sites with a high cover of *Austrodanthonia*, low growing wallaby grasses, several species of which have been inferred to be food plants for the subterranean caterpillars. The duration of the life cycle remains uncertain: although there are strong implications that it may be univoltine, developmental periods of two or three years have also been suggested. Eggs are laid at the base of grass tussocks, and the caterpillars feed on the grass roots. In southern Victoria, the adult flight season extends over about two months in late spring and early summer, with variations reflecting temperature and locality. Adult moths live for only a few days, and do not feed. Males patrol actively in search of mates, but females are relatively inactive. They are regarded as 'semi-flightless' and tend to rest on the ground, exposing their brightly coloured hind wings in response to males flying overhead. Males then land, and mating occurs. However, most males are active only at temperatures above about 22° C, on calm days in bright sunlight, and for a few hours in the middle of the day. Under other conditions, and at other times, their numbers can not be assessed. At least part of the reason for the putative scarcity of the moth reflects this aspect of the moth's activity. Some past surveys may have been undertaken under conditions or at times at which the moth would be unlikely to have been detected. Likewise, comparisons of abundance across sites are difficult to validate, and no more than a very few sites may be assessable by a single observer on any day because of the short daily flight period. Under suitable conditions, counts of active moths can be based on either transect walks or point surveys (Gibson and New 2007).

The short adult life also renders it impossible to obtain sound population estimates on any single visit to a site. All adults present on that visit are likely to be replaced by others by the following week, and not to have been present in the previous week: any single count can represent only the restricted emergence cohort present at that time, and this can not be reflective of the entire resident population present. Likewise, distribution patterns are equally hard to determine. Braby and Dunford (2006) and others have shown, by repeated visits spanning the whole flight season to

sites near Canberra, that the distribution of the moth may change dramatically as the season progresses. Rather than movement, this pattern may reflect differences in aspect and insolation across a site, so that emergences are earlier or later in different areas as a consequence of soil temperature. Local 'hotspots' of abundance may simply be 'hot spots'!

Recent surveys throughout the moth's range, and increasing biological understanding, particularly of its adult behaviour as above, are progressively leading to improved approaches to assessing its conservation needs, and dependence on particular habitat features and native grass food plants. Thus, following pioneering study of a population at Mount Piper, Broadford, O'Dwyer and Attiwill (1999, 2000) partially characterised favourable habitat for the moth and quantified some parameters of the needs for restoration of native grasses on degraded sites, as an initial model for wider appraisal.

In short, *S. plana* can be elusive in surveys, and its numbers difficult to quantify. This elusiveness, rather than genuine absence, has probably led to a misleading impression of its scarcity. It has often been declared absent (equated to population loss) on grassland patches, and to have disappeared from sites on which it has historically been reported. Some such losses are undoubtedly genuine, but others may not be, as improved searching capability continues to reveal additional populations throughout its range.

Conservation status

Synemon plana is listed federally as 'Critically Endangered', under the ACT and NSW acts as 'Endangered', and as a 'threatened species' in Victoria. These listings collectively cover the species' entire range.

At the time of Clarke's (2000) summary, *S. plana* was known to occur at few Victorian localities, with information suggesting that it had been lost from 48 of the 60 historically recorded localities in the state. Braby and Dunford (2006) noted its current presence on 31 sites in ACT and 42 in NSW. About 8 extant Victorian populations were known to Clarke (2000), but many more have since been reported (for example by Van Praagh [2004] and Endersby and Koehler [2006]). Many of the occupied sites are very small, of a few hectares or less, and many are indeed isolated grassland remnants. Threats to the moth noted for New South Wales include loss and degradation of habitat from agricultural and urban development, pasture enrichment with replacement of native grasses by exotic species, overstocking and overgrazing by domestic stock, weed invasion, and general fragmentation and isolation of remaining patches from a variety of developments. Similar threats and losses have occurred in Victoria and the ACT. Conservation management throughout the moth's range emphasises protection of the sites on which it is known to occur, particularly those on which the moth is adjudged abundant, so that *S. plana* is an important umbrella for less heralded taxa of native grasslands, as one of the few notable invertebrates characteristic of these ecosystems.

Despite obligations to conserve populations of listed threatened species, recent cases near Melbourne have given the moth some notoriety because of its presence on sites scheduled for housing or industrial development, and the needs to seek adequate compromise between conservation and development. Decisions to sacrifice the habitat of some (or parts of some) colonies have been justified by the moth's presence on other sites, but the wider view that the remnant grasslands themselves are now sufficiently scarce and vulnerable to merit total conservation is difficult to assert in the face of strong economic opposition. Many such sites are very small. Nevertheless, one outcome of this pressure from developers has been to stimulate further and more comprehensive surveys for the moth around Melbourne. However, in common with other listed threatened species, there is currently no formal 'centralised' system in which records of incidence of *S. plana* are progressively deposited, and many such records remain informal or in reports of very limited availability or circulation. Recent conservation interest has also been fostered by the discovery of the moth on a much larger suite of grasslands, the Craigieburn Grasslands Reserve and nearby Cooper Street grasslands, in work stimulated by plans for a

nearby freeway/ bypass (see Van Praagh 2004), where the moth is distributed over several square kilometres. Craigieburn Grasslands is the largest known habitat patch for *S. plana* in Victoria, and study of the moth there has been organised through the Merri Creek Management Committee and Parks Victoria. The site has potential to be a major reserve for the moth, and is sufficiently large to facilitate study of its populations and to trial manipulative management on a scale impossible on the more numerous small sites. Much of the survey protocol noted earlier (Gibson and New 2007) was based on observations at Craigieburn, for example. Because of its proximity to numerous other (small) grassland remnants in the outer Melbourne region, monitoring the flight period of *S. plana* at Craigieburn may be a valuable indicator of when to search for it elsewhere, so increasing the efficiency of further exploration.

Two additional inferences from recent studies are important contributions to the debate over the conservation status and needs of *S. plana*.

(a). Improved search methods are yielding new populations every season, and there now appear to be many more populations than earlier supposed. Whilst many of these may be vulnerable, a number are also in reserves, and there is considerable potential for practical conservation management to be instituted. Most of the work leading to knowledge of the moth's distribution flowed directly from its formal election as an endangered species. The major grounds for listing involved the fragmentation of habitat, and the progressive isolation of populations, with attendant vulnerability from continuing changes and disturbance to grassland habitat extent and quality. The advice to the federal Minister for the Environment from his Threatened Species Scientific Committee (2005) supporting the nomination for listing *S. plana* under the *Environment Protection and Biodiversity Conservation Act* emphasised also the lack of information on population sizes and dynamics of the moth, and acknowledged its very high abundance in places – but that many of those places were indeed vulnerable to fire and stochastic events, as well as to more predictable influences of weed invasion and other edge effects. This scenario remains valid, but the higher number of populations now known may lead to some downward revision of conservation status through affording greater collective security.

(b). The moth has been presumed to depend entirely and obligately on native grasses, predominantly *Austrodanthonia* spp. for larval food, so that the presence of these grasses, and their maintenance at high levels (O'Dwyer and Attiwill [2000] implied need for at least 40% cover of *Austrodanthonia* at Mount Piper) is a fundamental plank in the current conservation platform.

However, Braby and Dunford (2006) have raised the intriguing possibility that *S. plana* caterpillars might also feed on the roots of Chilean needle grass *Nassella neesiana*, an exotic weedy grass introduced from South America. The evidence is currently circumstantial, based on presence of pupal shells close to this plant in the ACT. This grass is present at Craigieburn and on some other Victorian sites. It is aggressive, and is a target for suppression to control its competition with native grasses. As Braby and Dunford (2006) have noted, further work is needed to clarify this possible association and the extent to which this weed is indeed used by *S. plana*. Some of the sites on which *S. plana* has been discovered recently near Melbourne appear to be substantially degraded, with relatively little *Austrodanthonia* present. Should its association with *Nassella* (or other exotic species) be found to be significant, the novel prospect may exist of needing to conserve selected populations of *Nassella* on sites where *Austrodanthonia* is sparse, at least as an interim measure to host the moth until more natural foods are plentiful.

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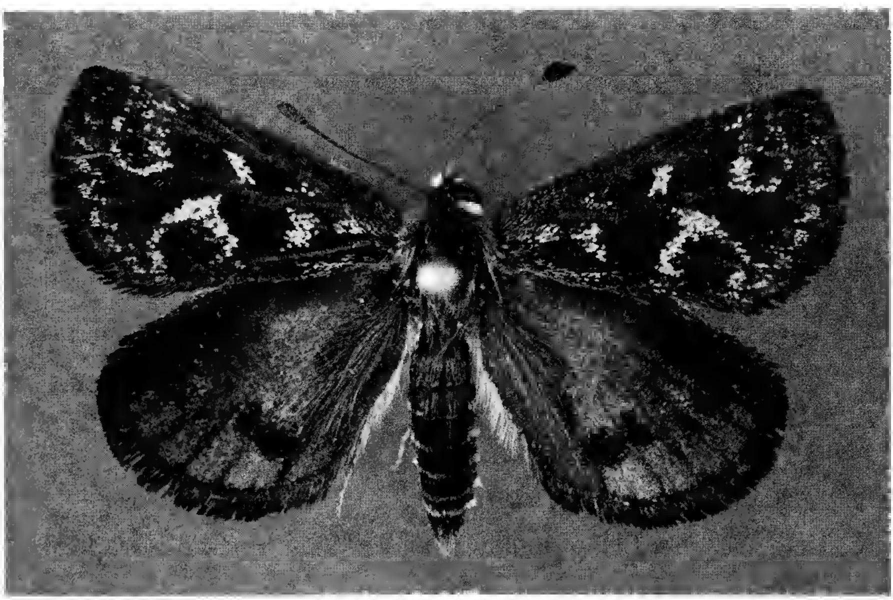

Museum specimen of a male Golden Sun-moth *Synemon plana*. Photograph supplied by Lucy Gibson.

The Lord Howe Island Stick Insect: an example of the benefits of captive management

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Abstract
Captive breeding is an underrated aspect of invertebrate conservation programs, sometimes seen as expensive and of little value to the overall conservation goal. The Lord Howe Island (LHI) Stick Insect project demonstrates the benefits of captive breeding, despite the inherent difficulties in dealing with a species about which nothing was known, which began in captivity with a small founder population, which has required a number of veterinary treatments and which has demonstrated apparent inbreeding depression requiring ongoing genetic management. *Ex situ* breeding at Melbourne Zoo has so far grown the captive population to more than ten times the wild population with very little financial contribution from participating organisations, ensuring a more secure future whilst *in situ* conservation measures are undertaken. (*The Victorian Naturalist* **124** (4), 2007, 258-261)

Introduction

In recent decades, habitat preservation has been increasingly recognised as an effective means of conserving threatened populations of invertebrates *in situ* (Hutchings and Ponder 1999; Yen and Butcher 1997), preserving not only the threatened species but others that may be vulnerable now or in the future (Samways 1999). As one part of this trend, some authors have suggested that captive breeding has little or no role to play in effective conservation programs (Collins 1990).

Present day recovery plans emphasise the importance of further biological research and the need for community involvement, protecting wild populations and threat abatement (e.g. Sands and New 2002), often without the need for captive breeding (e.g. Crosby 1990; Sant and New 1988). Those recovery plans that do include a captive breeding component often place it last in a long list of recommendations, and rarely is any serious attempt made to undertake this component.

However, there are many examples of threatened invertebrate species that would no longer exist in the wild or would not survive in their natural habitat long term, but for ongoing *ex situ* conservation programs (New 1995; Pearce-Kelly *et al* 2007). There are a number of advantages of captive breeding programs, including the collection of biological data more easily than in the wild, and management of the genetics of a threatened population/species to prevent inbreeding and maintain genetic viability (Pearce-Kelly *et al* 2007).

Some authorities recognise both *ex situ* captive breeding, including genetic management, as well as habitat preservation and threat abatement as the best means of ensuring the long-term security of threatened species (Clarke 2001; New 1995). The Lord Howe Island Stick Insect (LHI Stick Insect) *Dryococelus australis* recovery program provides a salient example.

The Lord Howe Island Stick Insect

The LHI Stick Insect (Fig. 1) was once common on Lord Howe Island, 700 km off the coast of New South Wales, Australia. The species became extinct on Lord Howe Island a few years after rats were accidentally released in 1918 (Gurney 1947), but was rediscovered in 2001 living on a small group of *Melaleuca* bushes on a rocky outcrop, called Balls Pyramid, 25 km off Lord Howe Island (Priddel *et al* 2003).

LHI Stick Insects were classified at the time as endangered under the New South Wales Threatened Species Conservation Act 1995 and presumed extinct in the IUCN Red Data List (IUCN 1983). A Draft Recovery Plan was developed by the New South Wales Department of Environment and Climate Change (NSWDECC) (Priddel *et al* 2002), and in 2003 two adult pairs were removed from Balls Pyramid for captive breeding. One pair went to Insektus, a private breeder in Sydney, the other pair to Melbourne Zoo.

Fig. 1. The original female LHI Stick Insect brought to Melbourne Zoo, feeding on Lord Howe Island Melaleuca *Melaleuca howeana*.

At that point almost nothing was known of their biology and ecology, other than observations made by Lea (1916). The remaining wild population is now thought to be less than 40 individuals, living on a few bushes on the side of a cliff on Balls Pyramid (Priddel *et al* 2003).

Captive management

LHI Stick Insects at Melbourne Zoo are kept under temperature and humidity regimes as close as possible to those of Lord Howe Island. The eggs are usually deposited in sand or crevices by the female (Fig. 2), and the nymphs emerge after 6-9 months (unpubl. data). In order to collect as much data as possible, each egg is removed from the sand, weighed, measured and placed in one of a range of incubation media.

Given that the biology of this species was virtually unknown upon its arrival at Melbourne Zoo, and there has since been no opportunity to make any effective observations of the wild population, there have been a number of difficult husbandry issues, including the near-death of the original female within a fortnight of her entering captivity. For the first two years of the project, there were no more than 30 individual LHI Stick Insects at Melbourne Zoo at any time, and ongoing attempts were made to rectify the low breeding and rearing success, focusing largely on husbandry and diet (as their natural diet on Lord Howe Island remains unknown).

Fig. 2. LHI Stick Insect eggs. These are generally buried by the female during oviposition.

The captive LHI Stick Insect population began to increase significantly in early 2006, and as of February 2007, the population at Melbourne Zoo is in excess of 500 individuals. This dramatic increase appears to have a genetic origin.

Genetic management

Many LHI Stick Insect specimens, particularly early in the breeding program, showed signs suggesting inbreeding problems. Eggs produced by the F1 generation were smaller in length, volume and weight than those produced by the wild-caught female, and had a lower hatching rate (unpubl. data). The nymphs were smaller and had a significantly lower survival rate, and adults showed morphological deformities, particularly in the final segments of the abdomen, consistent with inbreeding deformities seen in other insect species (pers. obs.). These trends continued for the next two generations. Inbreeding was considered as a factor but, due to the excep-

tionally small founder wild population, dietary and husbandry problems were considered to be more likely.

In June 2004, four adult males were swapped with those being reared at Insektus. In succeeding generations, the eggs increased in length, volume and weight; hatching rate increased and the nymphs were larger on hatching; and the morphological deformities no longer occurred (unpubl. data). A population increase followed in the next generation and a further, more dramatic increase in the following generation (Fig. 3), presumably due to the genetic input from the unrelated males. However, the evidence for inbreeding is still circumstantial and can only be confirmed by future genetic studies.

Conclusion

The LHI Stick Insect recovery program utilises both *in situ* and *ex situ* conservation measures, the captive management component being particularly important due to the perilous state of the wild population. Reproductive management, via crossbreeding of different gene lines using individuals identified with 'bee markers' (Fig. 4) is also essential to prevent inbreeding depression.

Although invertebrate conservation programs are now tending away from the single species approach to a more holistic habitat approach (Yen and Butcher 1997), there is merit in attacking the problem at both levels (Clarke 2001). However, this is not a widely accepted view. A conservation workshop on threatened invertebrates concluded that 'invertebrates can benefit from *ex-situ* conservation and re-introduction, but this is expensive and should be seen as the last resort.' (Hutchings and Ponder 1999). However, depending on how it is conducted, captive breeding can be relatively inexpensive and resource-efficient (Pearce-Kelly *et al* 2007). Two glasshouses at Melbourne Zoo easily house a population of LHI Stick Insects more than ten times the known population in the wild (Priddel *et al* 2003, D.Priddel pers. comm.), with very little financial contribution from either Melbourne Zoo or NSWDECC.

Once the appropriate approvals are obtained, LHI Stick Insects will be distributed to other institutions to further ensure the ongoing survival of the species. They will remain in captivity until the rodent eradication program, currently in the planning stage, is completed on Lord Howe Island. The LHI Stick Insect breeding program also illustrates that some invertebrate conservation programs are closely analogous to vertebrate programs when the species, such as the LHI Stick Insect, is high profile. It has the advantage that the project can act as a taxonomic surrogate for a number of vertebrate and invertebrate species within the same habitat, and as a flagship for threat abatement programs.

Acknowledgements

The LHI Stick Insect captive breeding program is currently being undertaken by Rohan Cleave,

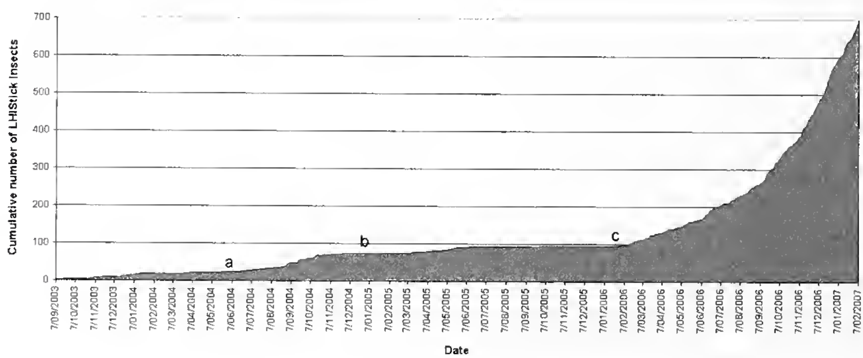

Fig. 3. Cumulative total of LHI Stick Insects hatched at Melbourne Zoo. Note that four new males were introduced in June 2004 (a); subsequent eggs began hatching six months later (b); and the next generation began hatching one year thereafter (c), leading to a dramatic population increase.

Norman Dowsett, Robert Anderson, Zoe Marston and other invertebrate keepers at Melbourne Zoo.

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Fig. 4. A pair of adult LHI Stick Insects in their daytime retreat. Note the numbered yellow plastic 'bee markers' glued to the back of the thorax. The male (lower) is facing the opposite way to, and with his legs over, the female.

More animals seen on *Thryptomene*

Introduction

In *The Victorian Naturalist* volume 122 (4), I gave an account of arthropods and birds observed on a *Thryptomene* shrub between September 2003 and the end of August 2004 (Hubregtse 2005). This plant has continued to be a source of interest. I have found out a little more about some of the animals I recorded in my initial study, and observed an additional 36 species using the plant. Nineteen of these were seen between 1 September and 31 December 2004. Subsequently, with the continuing dry weather, the number of arthropods seemed to decrease, and at the time of writing (10 March 2007) the shrub is under stress.

Animals seen

The animals I found included arthropods from three additional orders (Odonata, Blattodea and Neuroptera), and three more species of passerine birds.

Arthropods

Araneae

Another four types of very small spider were noted. One of these was a tiny brown flower spider with a triangular-shaped abdomen that had a small projection at each point of the 'triangle'. When alarmed, this spider tucked its legs under its body and stayed very still, looking just like one of the dead *Thryptomene* flowers – a disguise that no doubt helped it avoid being captured by marauding wasps. There were two more types of spiny-legged lynx spider (Ixyopidae): one was pale yellow, while the other had brown legs and cream and dark brown markings on its body. There was also a light orange-brown spider with a very smooth body and smooth legs.

Odonata

A medium sized dragonfly with a brown body and brown edges on its wings alighted on the shrub on 10 October 2004 but flew away as soon as I approached it.

Blattodea

A species of brown cockroach was seen in the shrub on 11 December 2004.

Mantodea

Both the brown and green mantids have been present each year, and were seen eating Honey Bees *Apis mellifera* in March 2006. During January 2006, there were also some larger, paler green mantids with short antennae and transverse yellow stripes on the underside of the abdomen. One unfortunate individual climbed on to a window frame and was squashed when a sudden gust of wind slammed the window shut.

Orthoptera

A green katydid spent some time in the shrub at the end of November 2004.

Phasmatodea

In February 2005 I found what looked like a piece of curled up dry grass hanging on one of the twigs. Close examination revealed the remains of a young stick insect bound in spiderweb. I hadn't seen a stick insect anywhere in our garden since January 2004; nor had I realised that spiders prey on them.

Hemiptera

In mid December 2004, a cotton wool-like substance appeared on a couple of the twigs, probably indicating the presence of mealy bugs. At the end of December I discovered that the wings of the grey leaf hopper (Ricaniidae), seen previously, can be creamy-coloured. I thought I had found another type, but within four hours the wings had turned grey. On 26 January 2005, a black and orange assassin bug (Reduviidae) (Fig. 1) clambered about on the twigs, searching for prey.

Neuroptera

I found a lacewing egg on 21 December 2004 and a larva, camouflaged in bits of plant debris, on 19 January 2005.

Coleoptera

Two more types of beetle, a black and yellow ladybird beetle (Coccinellidae) and a big brownish grey longicorn beetle (Cerambycidae) (Fig. 2) with orange coloration at the base of its antennae, were seen. The longicorn beetle had been injured.

Fig. 1. Assassin bug.

pinkish with brown markings). Also present were *Hellula hydralis* (Pyralidae) and three unidentified moths. At rest, one of these resembled a tiny, thin, yellowish bit of stick; another was slender and dull brownish grey; while the third, not observed until February 2007, was dark brown, shaped a bit like a Light Brown Apple Moth *Epiphyas postvittana* but smaller, and was seen only after sunset.

A Cabbage White *Pieris rapae* paid a brief visit to the flowers on 17 January 2005. This was the first time I had seen this butterfly land on the shrub, although one or more usually flew past it several times per day during spring, summer and autumn. On 2 February 2005, 142 mm of rain fell, followed by a further 7 mm the next day. On 4 February, a Cabbage White spent quite some time visiting the flowers, perhaps because they produced more nectar after the rain. On March 2005, a small dark brown butterfly with three creamy white spots on each forewing landed on a twig. A Caper White *Belenois java* did likewise on 18 October 2006. There were no flowers by this time because, for the first time ever, flowering finished at the beginning, rather than the end, of October.

Fig. 2. Injured longicorn beetle

Diptera

Three additional members of this order paid a brief visit to the plant: a cranefly, larger than the species seen in 2003-4; a blowfly with a creamy-coloured end to its abdomen; and a brownish grey bee fly with three yellow stripes on its abdomen.

Lepidoptera

Nine more types of moth and three more types of butterfly were observed. Five of the moths belonged to the family Oecophoridae: *Eochrois pulverulenta*, pinkish brown in colour; two *Thema* species, looking like scraps of dead leaf; and two *Tortricopsis* species (*T. uncinella*, shaped like a buff-coloured isosceles triangle, and a *Tortricopsis* species that was

Hymenoptera

There were another six species in this order: a Braconid wasp (Braconidae) with a black head and abdomen and brown thorax; a slender black wasp (Vespidae) with four yellow stripes on its abdomen; a small black wasp (Sphecidae) dragging a paralysed orange-brown spider – the smooth-bodied one – along a twig; a very tiny bee, rather like a miniature Honey Bee; a small bee with several narrow stripes on its abdomen; and a Bluebanded Bee (Anthophoridae) (Fig. 3), not seen before January 2007.

Arthropods in cocoons

The contents of most cocoons present in

Fig. 3. Bluebanded Bee on Lemon Balm.

2004-5 were eaten (see below). I once saw a caterpillar poke its head out of a cocoon, so I think some of these structures were being used as shelters. I suspected as much when, in my original study, I found caterpillar frass in one of the cocoons.

Birds

Passeriformes

By the end of November 2004 Little Wattlebirds *Anthochaera chrysoptera* had taken over the territory from the Red Wattlebirds *A. carunculata*, though the latter were still seen from time to time. From 28 December 2004 to 15 January 2005, and again on 15 February 2005, a Little Wattlebird devoured the contents of cocoons on the shrub. It also fed from the flowers and pecked at something on the twigs. Two New Holland Honeyeaters *Phylidonyris novaehollandiae* fed briefly from the flowers on 12 February 2006. Interestingly, these birds were using the plant principally for concealment as they quietly approached the adjacent *Grevillea* 'Robyn Gordon', remaining undetected by the wattlebirds for just long enough to consume some nectar before being discovered and chased away (Hubregtse 2006). On 9 January 2007 a male Common Blackbird *Turdus merula* perched on a branch and looked around for anything edible.

Conclusion

Having now seen about 130 types of animals from 15 different Orders, I continue to be amazed at this plant's ability to attract such a wide variety of creatures. Regrettably, the dry weather is taking its toll and the shrub has been under stress for some time. Although there are many flower buds, most are drying up and going brown before they open, so they are not attracting insects. There are now few spiders, hardly any wasps, and I have seen only two praying mantids this year. I supply water at legal intervals in hope of saving this shrub, which has been such a source of pleasure and fascination during the past 12 years.

Acknowledgements

I am indebted to the Discovery Centre staff at Museum Victoria, for answering many queries about the arthropods seen.

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Invertebrate herbivory of the Soft Tree-fern *Dicksonia antarctica*

There are few studies detailing the invertebrates found on the Soft Tree-fern *Dicksonia antarctica*, particularly in Australia. This Naturalist Note reports on observations made from Soft Tree-ferns growing at Baw Baw National Park in a Cool Temperate Rainforest pocket along the Mt Erica Road.

Observations were made on 18 April 2005 from about 11 a.m. to 2 p.m. on a clear day. A 30 m buffer zone from the road was allowed so that any possible edge effects were minimised. Every Soft Tree-fern along a 45 m transect running parallel to a small stream was carefully examined for the presence of any invertebrates on the fronds and for any sign of damage on the fronds. Damage was designated three levels: low – where only tips of secondary pinnae were damaged; moderate – where signs of damage occurred anywhere along the length of secondary pinnae; high – where only the rachis of the frond and the mid veins of primary pinnae remained.

The trunk height of each Soft Tree-fern was measured, number of fronds counted and each frond designated a level of damage. Whether or not Soft Tree-ferns were in an 'open' or 'closed' habitat was noted. An 'open' habitat meant that the tree-fern did not have other trees, debris or boulders beside it, i.e. one could walk around it unhindered. A 'closed' habitat meant that one could not walk unobstructed around the trunk. Finally, leaf litter accumulation within the depression formed at the top of the trunk by the emergence of the fronds was measured. Invertebrates often live within litter but move from it to feed, thus it was thought that if more litter was present, more invertebrates might occur.

Seventeen Soft Tree-ferns were examined. All exhibited herbivory by invertebrates. Twelve invertebrate species were identified (Table 1). All were herbivorous except the trapdoor spider and ants. Seven were chompers, two were stem borers and one was a sap sucker (Table 1). The trapdoor spider was carnivorous while the ants 'farmed' the treehoppers, feeding on the sugary substance they secreted. The trapdoor spider and snail were found on the trunk of one of the tree-ferns, the Darkling Beetle within the litter, and all other species on the fronds.

Tree-ferns ranged from 45 to 190 cm with a mean height of 105 cm. The number of fronds ranged from 7 to 28 with a mean of 16. There was a positive correlation between height and the number of fronds (Fig. 1) ($r = 0.77$, $df = 16$, $p < 0.01$). There also was a significant correlation between tree-fern height and the degree of frond damage (Fig. 2) ($F_{2,31} = 7.83$, $p = 0.002$). A *Post hoc* test showed that taller Soft Tree-ferns had lower levels of damage than shorter Soft Tree-ferns. This was not related to the number of invertebrate species per tree. Similarly, there was no significant difference between the number of fronds on a tree-fern and the degree of frond damage ($F_{2,31} = 1.36$, $p = 0.27$) although trees with fewer fronds tended to have higher levels of damage (Fig. 3). This

Table 1. Invertebrates on the Soft Tree-fern

Common name	Order	Family	Feeding strategy
Bug Nymph	*Hemiptera*	*Acanthosomatidae*	Chewing
Crane Fly	*Diptera*	*Tipulidae*	Chewing
Darkling Beetle	*Coleoptera*	*Tenebrionidae*	Chewing
Psyllid	*Hemiptera*	*Psyllidae*	Chewing
Treehopper	*Hemiptera*	*Membracidae*	Sapsucking
Weevil (sp. 1)	*Coleoptera*	*Curculionidae*	Stem-boring
Weevil (sp. 2)	*Coleoptera*	*Curculionidae*	Stem-boring
Snail	Class: *Gastropoda*	?	Chewing
Slug	Class: *Gastropoda*	?	Chewing
Caterpillar	?	?	Chewing
Ants	Hymenoptera	?	Farm treehoppers
Trapdoor Spider	*Arachnidae*	*Nemesiidae*	Insectivorous

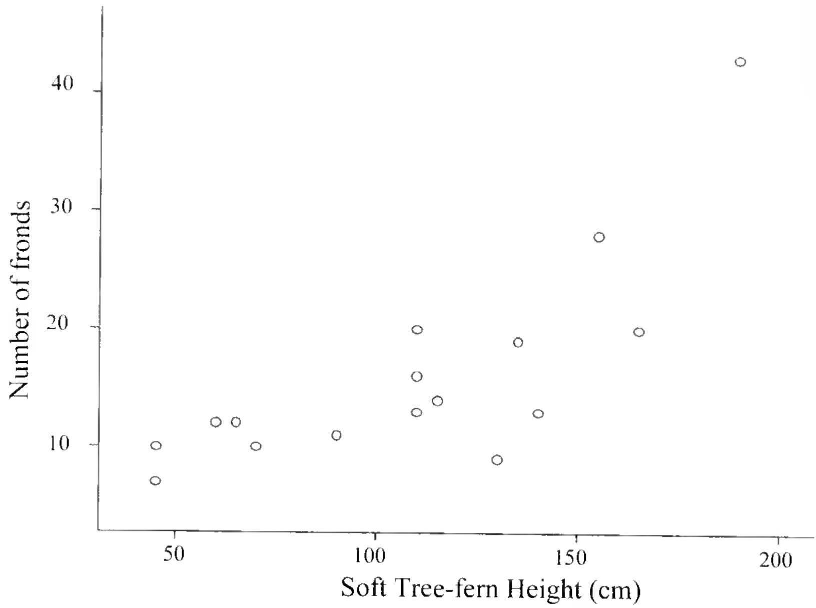

Fig. 1. Comparison of Soft Tree-fern height with the number of fronds.

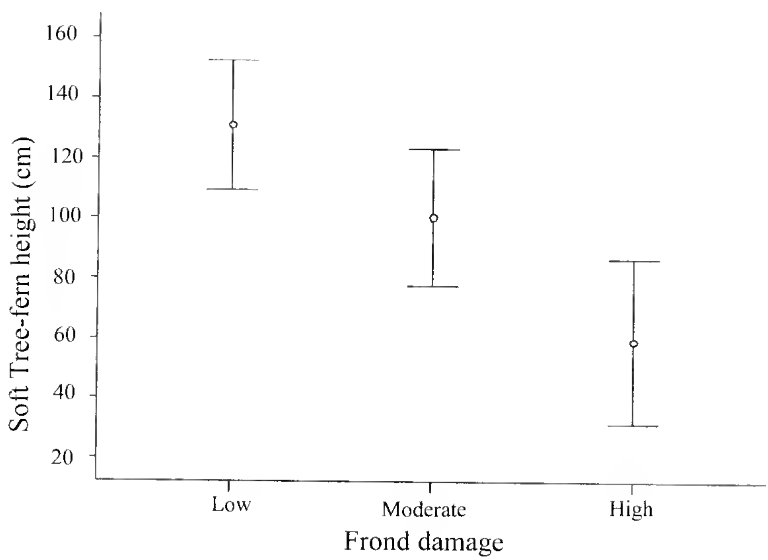

Fig. 2. Variation in frond damage with Tree-fern height

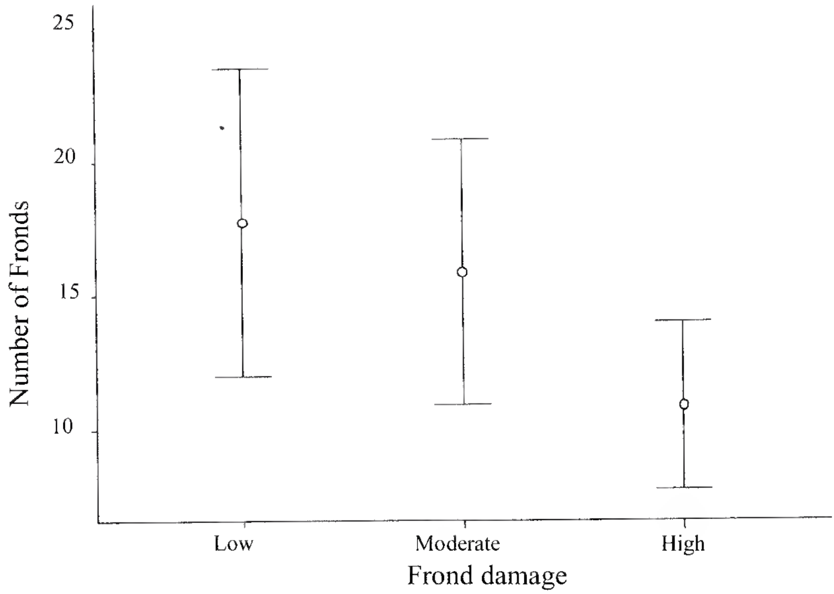

Fig. 3. Comparison of the number of fronds per tree with degree of damage.

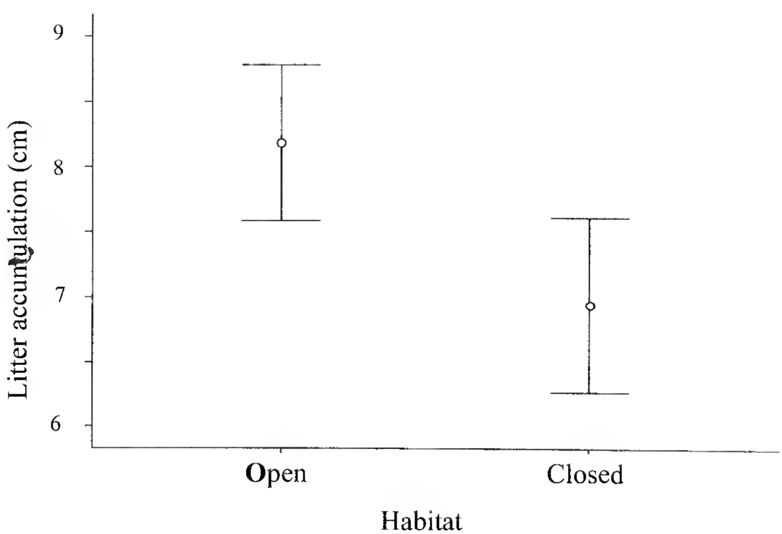

Fig. 4. Variation in litter accumulation at the base of fronds with habitat type.

is understandable as trees with fewer fronds were shorter than trees with higher numbers of fronds. There was no significant difference between the number of invertebrates and the degree of frond damage ($F_{2,31} = 0.63$, $p = 0.54$). Shorter trees are more accessible to ground dwelling invertebrates, possibly explaining why they could show higher levels of damage than taller trees in spite of there not being a significant correlation with number of invertebrates.

Ferns in an 'open' habitat had significantly higher amounts of leaf litter in the depression caused by emergence of fronds from the trunk than ferns in 'closed' habitats (Fig. 4). Litter depth within the depression caused by emergence of the fronds from the trunk ranged from 2 to 11 cm but there was no significant correlation between the number of invertebrate species and litter depth. Neither was there a significant difference between fern habit and the number of invertebrates recorded.

Conclusion

Observations for this note were taken over a three hour period on a single day. It often is perceived that ferns are not particularly edible but the extent of damage to some fronds, i.e. only stalks left, shows that this is not the case. Whether or not this was caused by the types of invertebrates found is unknown and would require further study. However, it is amazing how much information can be gleaned over such a short time period. Hopefully this note encourages others to look more closely when they wander out into the bush, and to publish their short term observations.

Acknowledgements

Grateful thanks go Maria Gibson for helpful suggestions and comments on this small project and to Cuong Huynh for identification of the invertebrates. Both belong to the School of Life and Environmental Sciences, Deakin University.

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One hundred Years Ago

ICHNEUMON MAIMED BY SAW-FLY. - During the end of April and beginning of May I had under observation a saw-fly, Perga lewisii, Westw., guarding its larvae on a branch of Eucalyptus amygdalina. On the 6th of May I noticed an ichneumon amongst the larvae, while the saw-fly was on the leaf, apparently contentedly watching. Mr. Edmund Jarvis and myself examined the ichneumon, and found that its antennae and ovipositor were missing. While it was under the influence of a dose of cyanide of potassium Mr. Jarvis noticed it eject some eggs through the remaining stump of the ovipositor. The incident is interesting, as it is probably the first case recorded of this species of Perga having rendered the parasite harmless. In the accompanying exhibit the ichneumon minus its antennae and ovipositor is shown; the eggs can hardly be seen, as they have shrivelled, but an enlarged drawing is shown. - J.P. M'LENNAN. Emerald, Victoria, 8/6/07.

From *The Victorian Naturalist* **XXIV**, p 60, July 4, 1907

The Hemiphlebia damselfly *Hemiphlebia mirabilis* Sélys (Odonata, Zygoptera) as a flagship species for aquatic insect conservation in south-eastern Australia

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Abstract

The endemic damselfly *Hemiphlebia mirabilis* Sélys has been a focus of conservation attention since its rediscovery in Victoria was publicised in the mid 1980s. It was listed under the state's Flora and Fauna Guarantee Act (FFG) in 1991. Discovery of additional colonies has indicated that *Hemiphlebia* is far more widespread than earlier supposed, and continued study indicates that it is variously secure or vulnerable in different places – rather than 'endangered', as previously thought. The history of study of the species is summarised briefly, and its values in promoting awareness of insect conservation as a 'flagship species' in southern Australia are discussed. (*The Victorian Naturalist* **124** (4) 2007, 269-272)

Introduction

The Hemiphlebia damselfly *Hemiphlebia mirabilis* (Fig. 1) is now also known as the 'Ancient Greenling' (Theischinger and Hawking 2006). It is well known as one of Australia's most unusual endemic damselflies. It is commonly referred to as a 'living fossil', and is treated conventionally as the only extant member of the superfamily Hemiphlebioidea, implying that it is taxonomically isolated within the order Odonata. Indeed, Trueman (1996) believed that it was the sister-group to all other Odonata. This isolated position, rendering it a distinct 'oddity' within the order, is implied by unusual wing venation and the form of the larval labium. Trueman (1999) reappraised both characters and suggested that they may in fact be derived, rather than primitive as commonly presumed. *Hemiphlebia mirabilis* is also of interest for its elaborate display behaviour, and is one of the smallest Odonata.

Fig. 1. Male *Hemiphlebia mirabilis,* Wilsons Promontory, Victoria.

Much of its conservation interest arises from its putative isolated phylogenetic position, coupled with the belief that it might have become extinct in the mid 1970s, due to habit loss through agricultural intensification in the Yarra and Goulburn valleys, Victoria. Over that period, a number of searches failed to yield the insect, which appears always to have been highly localised and known from few places. Thus, Wells *et al.* (1983) categorised it as 'endangered', at a time when it was believed to be extinct, and Moore (1982) placed it as the highest global priority for conservation of the then newly formed Odonata Specialist Group of the World Conservation Union's Species Survival Commission. *Hemiphlebia* was thus something of a 'holy grail' for Australian dragonfly enthusiasts, but it was not until Davies (1985) publicised a record by Garrison from Wilsons Promontory and established its presence there for himself, that its continued existence was confirmed, and the conservation status and biology of *Hemiphlebia* could be appraised in more detail. In this note, I recapitulate briefly the sequence and extent of data accumulation on *Hemiphlebia*, and indicate how this has led to more realistic appraisal of its conservation needs, and also explore the wider context of *Hemiphlebia*'s importance in developing insect conservation awareness in Australia. The species is amongst the few invertebrates already the focus of conservation interest at the time FFG came into force, and has remained so ever since.

Biology and Conservation

Although *H. mirabilis* was stated to have been described from Port Denison, Queensland, this locality citation is now accepted generally as erroneous for Lake Denison, Victoria, which has long been drained but is in the same general area as all other mainland distribution records. Davies (1985) documented a strong colony in Wilsons Promontory National Park, which was explored further in 1987-1988 (Sant and New 1988), to clarify its life history further, to characterise its habitat as far as possible, and to explore its distribution on the northern part of the park. Wilsons Promontory was then the only place known to support *Hemiphlebia*, but subsequent searches showed it to occur in the Goulburn Valley as well, both at Yea and near the billabong at Alexandra, from where Tillyard described the larva and found the damselfly over a long period (1906-1931: ANIC records, see Watson 1995) (Trueman *et al.* 1992). *Hemiphlebia* was also found to be quite abundant at localities in north-east Tasmania and on Flinders Island (Endersby 1993; Trueman *et al.* 1992), with the implication that it formerly may have occurred more extensively across the eastern land bridge that linked Tasmania with south-eastern Victoria.

Hemiphlebia is univoltine, with adults present from late November to late February. Adults are very cryptic, and are inconspicuous when they rest on dense vegetation. The usual habitat is densely vegetated seasonal swamps/ billabongs/ lagoons, with shallow (often 20-60 cm deep) water and with the margins seasonally dry. Many formerly suitable habitats, particularly in the Goulburn and Yarra valleys, have been destroyed or degraded severely by drainage and cattle trampling. Fringing areas with dense reeds or other emergent vegetation appear to be critical habitat components, with seasonal desiccation suggesting strongly that *Hemiphlebia* has a well-developed mechanism for overcoming periods of drought, possibly as the egg stage. Larvae are small in early spring, and their main growth phase is from August to November: there appear to be 9 or 10 instars.

Hemiphlebia was a natural candidate for early nomination for protection under FFG, as a formal prelude to preparing an Action Statement on its conservation status and needs. Grounds included in the nomination (April 1990) were that (1) it had disappeared from localities in the state where it previously occurred; (2) is primarily threatened by habitat degradation, particularly involving drainage, damage by cattle, and river regulation; (3) that the Wilsons Promontory population was threatened by park management practices; and (4) that the species is rare in terms of abundance and distribution. Together with uncertainties over the recovery from a major burn of the largest known colony on

Wilsons Promontory (1987), *Hemiphlebia* was a strong candidate for listing, and it was formally listed in May 1991 as one of the first batch of non-marine invertebrates to be so designated.

Progressive accumulation of information on *Hemiphlebia* has led to informal down-grading of conservation status, with various sites now regarded as secure or vulnerable, notwithstanding Watson's (1995) comment that 'its future can be regarded as secure'.

The major concern for its welfare in the late 1980s centred on the outcomes of a fire at Wilsons Promontory. The main habitat of *Hemiphlebia*, on Five Mile Road, abutted a fire break mown along a road, and a control burn (part of the management strategy to regenerate heathland along the northern part of the National Park, to reduce ground fuel loads, and to provide a barrier to passage of more severe uncontrolled blazes) got 'out of control' and swept through the swamp, with potentially severe consequences; it was feared that the damselfly might have been extirpated.

In fact, the mown area, across about half the swamp area, remained green. However, the very dry summer and autumn also led to concentration of cattle seeking water – at this time, the region was part of a long-term grazing lease, phased out in 1992 – which led to considerable trampling of the swamp. Factors causing concern for the colony were (1) loss of emergent vegetation, increasing exposure of the water; (2) deposition of ash on the water; and (3) increased cattle access, trampling and dung deposition. Subsequently the area was fenced by the parks staff to exclude cattle. The fence was left in place for some seven years, whilst the area had a chance to recover. Subsequent monitoring (New 1993) showed gradual recovery of *Hemiphlebia*, apparently reflecting that the mown part of the habitat constituted a refuge for part of the population, and numbers of adults gradually increased in the entirely burned area. Recovery from severe habitat disturbance is clearly possible, and it is likely that *Hemiphlebia* may have experienced numerous similar catastrophes during its long history.

Indeed, if we categorise the major threats to native invertebrates in Australia, the top concerns would be habitat change through vegetation clearing, impacts of exotic (often, invasive) organisms, and agricultural practices. All are relevant to *Hemiphlebia*, with the last-named the most significant impetus for habitat degradation. Nevertheless, and despite evidence of its widespread survival, *Hemiphlebia* does appear to have been lost from some former inhabited sites, with agriculture and cattle clearly implicated in this decline. The small number and dispersion of colonies currently known merits its retention as a species of conservation significance. Some colonies in both range-states are in National Parks, so that opportunity for practical management is present, and methods of habitat maintenance are reasonably clear – with ambiguities over the extent of disturbance that may be tolerated. It is likely that *Hemiphlebia* will be more widespread than the few current disjunct records imply, although searches have so far failed to confirm this and more detailed surveys, particularly through the Goulburn Valley, are warranted.

Discussion

As well as being a species of significant conservation interest as a 'target', *Hemiphlebia* also has become a notable flagship species, as a wider conservation 'tool'. As a member of a small portfolio of ecologically disparate invertebrates targeted for conservation in Victoria, all of which were promoted under FFG in its early years, it has helped to make many people aware of the ecological variety of invertebrates and their conservation needs.

Flagship species are 'ambassadors', helping to communicate importance and conservation lessons to a wider audience and to increase appreciation of the 'place' of invertebrates in natural systems. Because of its presence in National Parks, *Hemiphlebia* has had a special role in helping to get invertebrates included in park conservation agendas. Particularly at Wilsons Promontory it has been accepted by staff as one of 'their' special species, with staff being aware of where it occurs and its significant interest. This increased awareness has had a wider impact. In

Australia we have no coordinated inventory program to document invertebrates in high quality reserves, and most records are simply serendipitous. Odonata, thanks to recent handbooks (Watson *et al.* 1991; Theischinger and Hawking 2006) are largely identifiable to species level as adults and larvae, and an increasing number of park surveys is being instigated as a basis for evaluating species' representation on reserves, to provide a sound template for future complementarity of protected areas.

The cryptic nature of *Hemiphlebia* means that, unlike more conspicuous insects such as butterflies, most people who support its conservation strongly have never seen it alive, but nevertheless accept it as important.

Whereas *Hemiphlebia* is now known from two states, with the strong implication that it has been distributed more widely in the past (so that present colonies are remnant populations), it is still known from relatively few localities and has not been found west of Melbourne, on King Island or north-western Tasmania, so that it may never have occurred on the western land bridge region. It may well occur elsewhere, but is elusive, and has successfully evaded detection during numerous comprehensive surveys of aquatic invertebrates throughout the state undertaken through Museum Victoria. It is clearly resilient to disturbance, but not to loss of habitat, and appears to fly weakly and thus to be a feeble disperser. Individual site/colony management is thus the key to practical conservation but, as for many other invertebrates, 'management' may mean prevention of major change or intrusion, and – in some cases – possibly changing land tenure to help meet this basic need. Its conservation needs thereby reflect it satisfying both the 'small population' (thereby being susceptible to stochastic effects in small areas) and the 'declining population' (implied, without solid population data, and reflected in overall decline in range) of Caughley (1994).

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Conservation of mayflies (Ephemeroptera) especially *Coloburiscoides* in the Victorian Alps: impediments and threats

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Abstract

The aquatic insects are still poorly represented in terms of conservaiton and protection in Victoria. The main impediments for this were identified over a decade ago and all remain valid today. Recent national collections of aquatic invertebrates have been used to determine distribution and habitat requirements for more than 200 macro-inveterbrates, and this has enabled the identification of a number of species that have restricted distributions and may be candidates for conservation listing. An example, using the mayfly genus *Coloburiscoides*, highlights how the perception that these animals are widespread and common may mask the reality of individual species being rare and restricted in their distribution, and that the effects of climate change may hasten their decline. (*The Victorian Naturalist* **124** (4) 2007, 273-277)

Introduction

The aquatic insects, although highly diverse in Victoria, are very poorly represented in terms of conservation and protection. Under the *Flora and Fauna Guarantee Act* there are only 13 species of aquatic insect classified as Critically Endangered, Endangered, Threatened, Vulnerable or Data Deficient. Only caddisflies (Trichoptera) and stoneflies (Plecoptera) have a conservation status under the Act. This implies that aquatic insects are not of major concern for conservation, but there are a number of important reasons for the absence of many of the other insect orders. Butcher and Doeg (1995) identified a number of reasons for this including poor taxonomic knowledge, the incomplete knowledge of insect life cycles, poor systematic collections that give good knowledge of distributions, and the lack of coordination between organisations that collect from the aquatic habitats.

All these impediments still exist today even though there has been considerable effort to rectify these shortcomings. The Cooperative Research Centre for Freshwater Ecology held taxonomic workshops that targeted many of the aquatic insect groups and other aquatic invertebrate groups to provide reliable keys to 'voucher' taxa based on morphological characteristics of the nymphal and larval stages. This recognised that much of the taxonomy of the aquatic insects was based on the short lived adult stages, but the biological assessment of rivers throughout Australia was dealing with the juvenile stages, which are long-lived, but not associated with adults. These workshops increased the taxonomic work on the aquatic insects' nymphs and larvae, and addressed the coordination issue by providing a voucher name or number based on the best taxonomy available.

Also, since the paper by Butcher and Doeg (1995), there has been a series of national collections (e.g. Monitoring River Health, First National Assessment of River Health) which have provided systematic collections using standard methods. These programmes used rapid biological assessment methods and the collections were identified only to Family level, thus limiting their value in providing distributional data for any particular taxon. However, a project to use these collections and identify some of the aquatic insects to the lowest taxonomic level (morphological voucher species) was undertaken by the Australian Biological Resources Study and the Natural Heritage Trust (Suter *et al.* 2006). This has enabled an assessment of the distribution, ecology and habitat use by some 200 taxa. This work has highlighted some conservation issues with a number of taxa that are only rarely recorded or are restricted in their distribution in Victoria.

Suter *et al.* (2006) recorded at least eight mayfly species (*Edmundsiops* MVsp. 9, *Pseudocloeon hypodelum* Lugo-Ortiz, *Wundacaenis flabellum* Suter, *Atalophlebia* AV2, *Atalophlebia* AV6, *Ameletoides* sp., *Tasmanophlebia* AV2 and *Coloburiscoides* sp.) and five caddisfly species (*Daternomina* AV11, *Ecnomina* AV3, *Ecnomina* AV22, *Ecnomus nibbor* Cartwright and *Hydrobiosella* AV4) that were restricted to less than five locations in Victoria. Only three of these species have been formally described and named, with all the others known only by their Australian Voucher Number. This highlights the taxonomic impediment that exists with the freshwater insects. Even though the taxonomic workshops enabled the identification of nymphs and larvae of the major insect Orders with illustrated keys, complete descriptions and formal naming has been limited, due to inadequate funding for taxonomic research. Consequently, there may be a number of extinctions that have already occurred but the species have never been recognised (Strayer 2006).

Coloburiscoides – perception may not be reality

The Family Coloburiscidae includes a single genus *Coloburiscoides* that currently consists of three described species and appears widespread throughout the Australian Alps in New South Wales, the Australian Capital Territory and Victoria (Campbell 1981; Marchant and Ryan 2006; Suter *et al.* 2006). Records also exist from streams in the Otway Ranges in Victoria (Suter *et al.* 2006) (Fig. 1). Nymphs of this genus occur in high altitude streams and in the foothill streams draining the Alps. Nymphs have been recorded at a wide range of altitudes from 10 m to 1860 m. They occur in fast flowing water in streams with a substrate dominated by pebbles, cobbles and boulders (Suter *et al.* 2006). They use their elaborate ornamentation of spines on their body and gills (Fig. 2a) to maintain their position between rocks, and the fine hairs that line the femora and tibiae of the forelegs and femora of the mid legs to filter fine particulate organic material from the flowing water. The nymphs live for at least a

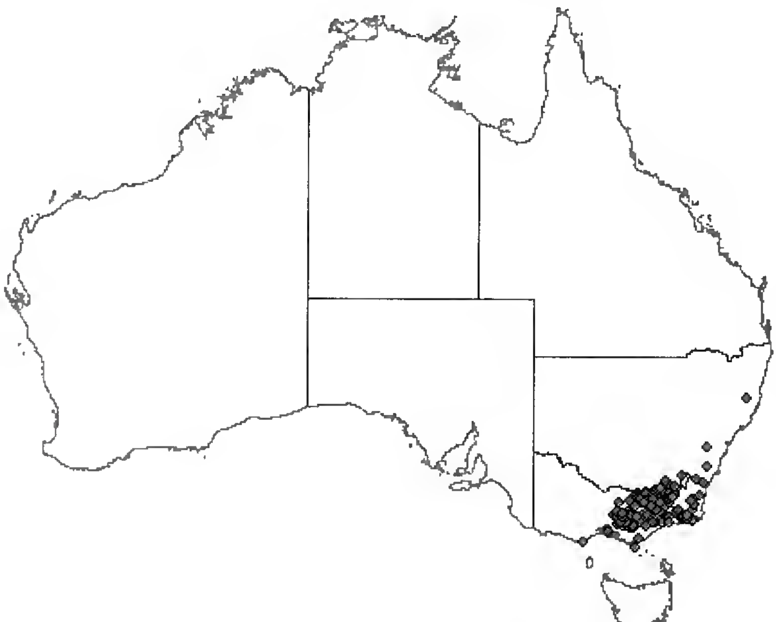

Fig. 1. Distribution of all species of *Coloburiscoides* in Australia based on collections made during the Monitoring River Health and First National Assessment of River Health.

year (maybe two years) (Campbell 1986) before they emerge as subimagoes (the Kosciuszko dun) but the imagoes or adults are rarely seen even though they are large (Fig. 2b).

Although evidence of this widespread distribution would suggest these animals are common and abundant there is a major concern in that the species can only be identified from the adults, and not from the more commonly collected nymphs. No reliable characteristics have been found to distinguish the different species in the nymphal form. Consequently, in ecological and biogeographical studies (Campbell 1981) all species are combined at the generic level, which provides the perception that this genus is widespread and common and that each species is also common. However, as with all combined data, there is a loss of information, and individual species may not be common or widespread but, in fact, be potentially endangered.

A recent study (McGuffie 2005) used mitochondrial DNA (cytochrome *c* Oxidase Subunit I gene; COI) to distinguish species of *Coloburiscoides* nymphs from numerous locations within the Australian Alps. These analyses indicated four distinct species based on the COI gene. Of these, at least two species had a very restricted distribution, limited to two or three locations. In addition these locations were at altitudes above 1000 m ASL with most in mountain top streams above the tree line.

The two species which are of major conservation concern are both endemic species; *Coloburiscoides giganteus* (Tillyard) from the Mt Kosciuszko area in New South Wales and an undescribed species currently known only from the Bogong High Plains. Both of these species are large (body size in adults and mature nymphs >20 mm) and occur in association with larger substrate particle sizes (cobbles and boulders). The smaller species (body size in adults and nymphs <18 mm) were associated with pebbles, sand and logs (McGuffie 2005).

These two species have the potential of being listed as Vulnerable, Rare or Threatened. *Coloburiscoides giganteus* has been recorded from only three locations in New South Wales: Diggers Creek (Kosciuszko National Park, KNP) Thredbo River at Dead Horse Gap (KNP) and Leather Barrel Creek (confirmed by adult and DNA analysis). There are unconfirmed records (adults only) from the Upper Macalister River and upper Western Tyers River in Victoria (Campbell 1983). The second species recorded from the Bogong High Plains is common in streams within the National Park and Falls Creek resort, but it appears restricted to this area above 1200 m ASL.

Threatening Processes

Butcher and Doeg (1995) gave a preliminary list of threatening processes for aquatic invertebrates (i.e. flow alteration, temperature changes, sediment input, removal of wood debris, inputs of toxic substances). In recent years, two major threatening processes have become apparent particularly in the Australian Alps: fire caused by lightning strikes, and climate change. Clunie and Reed (1995) noted that the *Flora and Fauna Guarantee Act 1988* gave the ability to list communities as threatened and thereby protect numerous species rather than individual species. The alpine habitats are so listed, but the threats of fire and climate change are still relevant.

Following the 2003 fires in the Australian Alps, the abundance of filter feeding aquatic invertebrates declined dramatically and *Coloburiscoides* nymphs in the foothills streams became rare to absent following runoff from burnt catchments. In the Tallangatta Valley where *Coloburiscoides* nymphs were abundant in the late 1990s only a solitary animal at one site was found following ash laden runoff in 2003 (Suter, pers. obs.). Similar reductions were recorded downstream of the Buckland River in the Ovens River catchment following a flash flood in 2003 (Anon 2003) with reductions in the macroinvertebrates and *Coloburiscoides* (raw data provided by the Victorian EPA). Other studies by the EPA (Anon 2004, 2006) also compared the river health changes post fire and noted that the impact of fire was related to the subsequent rainfall and runoff, patchiness of the fires and the sources of recolonisation (Anon 2006). The raw data from the EPA monitoring of the fire impacts indicated that *Coloburis-*

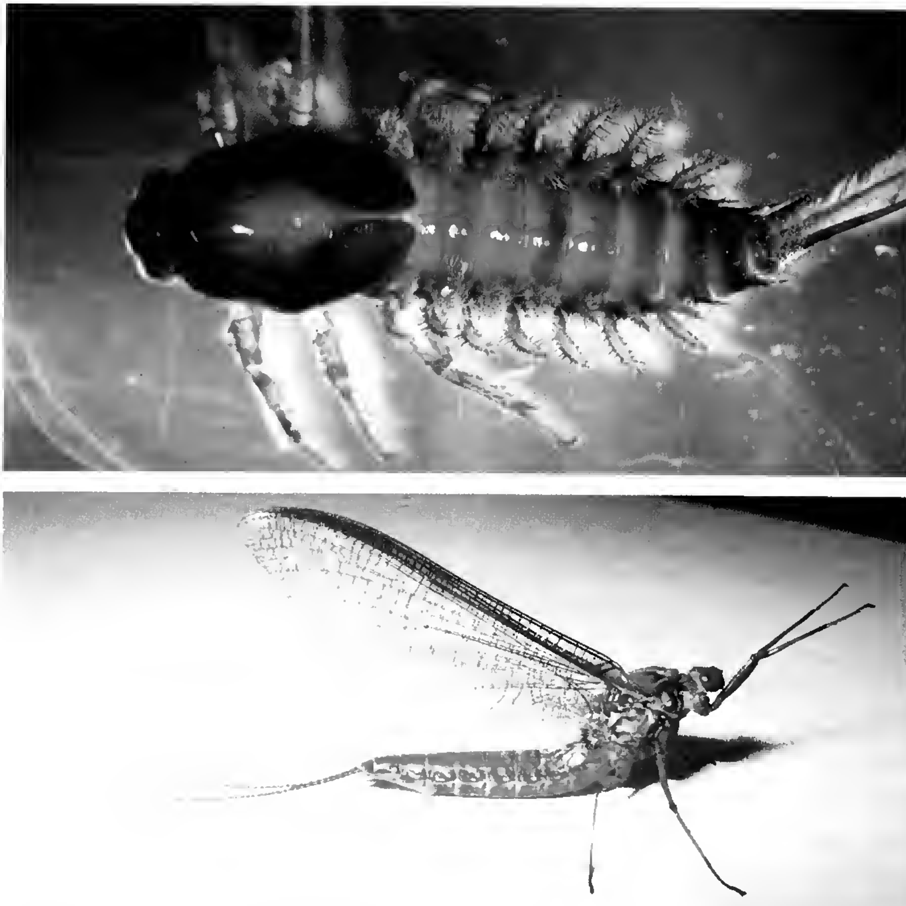

Fig. 2. Nymph of *Coloburiscoides giganteus* from Kosciuszko National Park (above), and female imago of *Coloburiscoides* sp (below) from the Bogong High Plains.

coides numbers did recover over an 18 month period after the fires. Crowther and Papas (2005) compared the macroinvertebrate communities of burnt and unburnt streams on the Bogong High Plains but *Coloburiscoides* was not mentioned as an indicator of river health change. Intense fire and runoff into streams of the alpine zone has the potential of eliminating some populations of *Coloburiscoides* from the limited locations where they occur. The threat of fires in the Australian Alps is likely to be increased with the second major threatening process, climate change. With predictions of between 2° C and 6° C increase in global temperature this century, the possible impacts on the alpine environment include a decrease in snow cover during winter, an increase in extreme frost events, altitude rise in the subalpine zone and a decline in the area of the alpine zone (Good 1998). Snow cover insulates the ground (Green 1998) and allows streams to flow beneath. Estimates of between 18% and 66% reduction in the area covered by snow by 2030 have been made by the Australian Greenhouse Office (Commonwealth of Australia 2002). Under reduced snow cover, the streams and peatlands may be exposed to freezing and thawing (periglacial activity) and a greater intensity of frost crystal formation and frost-heaving (Good 1998) leading to increased sedimentation (Ritter 2006) and reduction of available habitat for the long-lived aquatic fauna. A reduced runoff from snow melt

would also reduce the fast flowing conditions required by many of the aquatic invertebrates (Green and Osborne 1998). Animals that have long life cycles and are filter feeders, such as *Coloburiscoides giganteus* and *Coloburiscoides* sp., would be unlikely to survive such extreme conditions. In addition, another undescribed endemic mayfly *Ameletoides* sp. is also found in some streams on the Bogong High Plains and is subject to the same threats as *Coloburiscoides* sp.

Strayer (2006) considered that conservation of freshwater invertebrates, including insects, face five challenges:

1. thousands of species may already be extinct or imperilled
2. human pressures on water resources are intense and increasing
3. scientific knowledge of invertebrates is significantly poorer than for vertebrates
4. freshwater systems are part of a larger catchment and conservation should focus on all the catchment upstream and not on an individual site
5. society spends little on invertebrate conservation.

The habitat occupied by *Coloburiscoides giganteus* and *Coloburiscoides* sp. are at the top of catchments that are protected in national parks and are therefore not exposed to major human pressures, toxins or land clearance and subsequent erosion. However, despite having some protection these two species of *Coloburiscoides* are still under threat from lack of scientific knowledge, inadequacies of funding for invertebrate conservation and fire caused by lightning strikes and climate change, all of which increase their chances of becoming extinct or critically endangered.

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Dragonfly *Aeshna* sp. (Photograph from FNCV files).

Dainty Swallowtail *Papilio anactus* (Photograph from FNCV files).

A Guide to Australian Moths

by Paul Zborowski and Ted Edwards

Publisher: *CSIRO Publishing, 2007. 214 pages, paperback; about 400 colour photographs. ISBN 9780643091597. RRP approximately $40.00*

If you put together Ted Edwards, arguably the foremost authority on Australian Lepidoptera, and Paul Zborowski, a leading nature photographer, it should be enough to ensure an accurate and superbly illustrated book – and that is what you get for this reasonably priced publication.

However, don't expect to be able to go out on to your verandah, check your lights and be able to identify every moth you see battering itself against the globe. That is not the purpose of the book and you will be disappointed. With over three hundred and fifty adult species depicted you will recognise some, but with more than 20 000 species of moth in Australia and thousands in Victoria alone you can see the logistical problem.

Instead, the authors have chosen to present the range of moth families found in Australia. Some families with few representatives of rarely seen moths are excluded but every family we regularly see around Victoria is there. The sixty-nine families included are clearly and beautifully represented. Butterfly families (which any real Lepidopterist regards as day flying moths) are not included as they are covered by plenty of good publications already.

Getting to know any group, be it orchids, songbirds or beetles, is a challenge. You need to get your eye in and you need to know which bits to look at. Each family in this book has its own section with features to help the reader develop those skills. Heading up each family section is a list of between five and ten identifying points that give you a clue about the features requiring close scrutiny. A few technical words are used but there is a functional glossary where they are defined.

Next follows a brief note on the family, with information and superb colour photographs of the moths and sometimes the caterpillars. The photographs chosen illustrate the resting posture and general outline of the adult members of the families. Very large families such as the Noctuids and Geometrids have more photographs showing a representative cross-section. Each photograph is accompanied by an informative note on the biology of the species.

The extensive introduction gives considerable information about moths and their general biology. It is written in an easily understood style lightened by the occasional wry comment. (Adult moths have a 'short but not-so-sweet life'.)

But that's not all . . . Scattered through the pages are some gems – short articles on related subjects that give some great angles on the group. For example there is information on the moths that use wombat poo to fatten up before pupating. A fascinating discussion on the role of moths on bushfire moderation is a must-read for anyone who is concerned about the proper management of our forests.

This book is to be recommended. It is an intelligent and clear introduction to the moth fauna of Australia, suited to those who would like to understand more about this order of insects. For a precise identification the reader will need to go elsewhere (the book even gives places to go). Using this text will provide a much sounder basis for managing the search.

Peter Marriott
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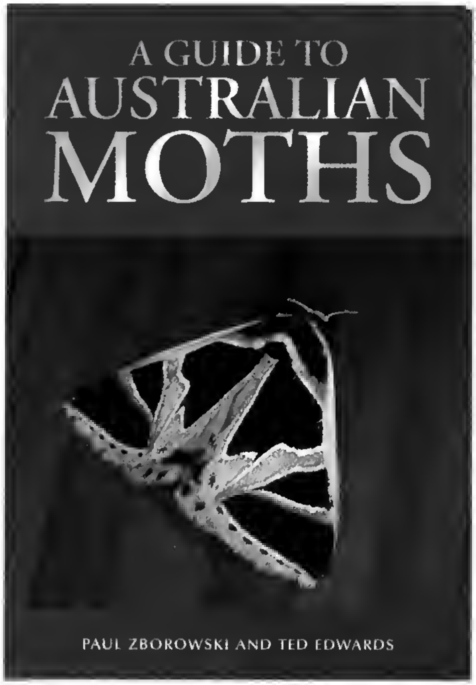


Melbourne's Wildlife: a field guide to the fauna of Greater Melbourne

By Museum Victoria

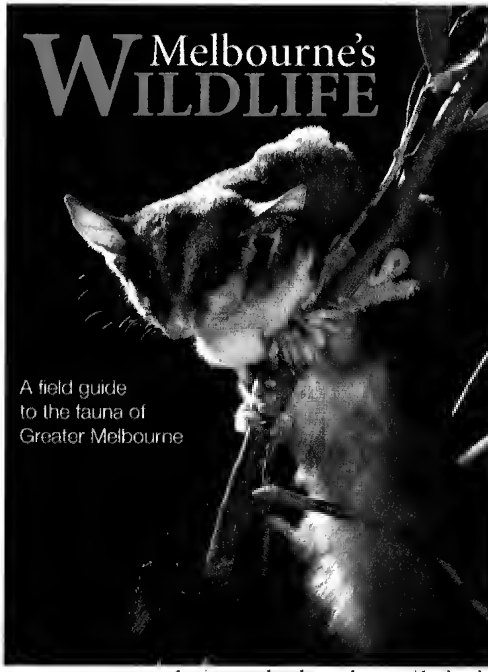
Publisher: *CSIRO Publishing, 2006. xii + 348 pages, paperback; ISBN 100643092544. RRP $39.95*

In his foreword to this book, John Landy says it is '... a distillation of the knowledge of the museum's science department' and nineteen authors have contributed, most of them currently or previously with the Museum.

Scope

Planned to be the Victorian counterpart to similar books published by the Queensland Museum, its purpose is to allow identification of a large selection of species through the use of photographs and text. Each entry includes identification, habitat and range, and notes. Terrestrial and freshwater environments and marine environments are covered. The first section consists of insects and other invertebrates, fish, frogs, reptiles, birds and mammals. Marine creatures are divided into sections for sessile invertebrates, jelly-like or free-floating, worms, echinoderms, molluscs, crustaceans, fish and mammals. With usually three species to a page, identifications are offered for 522 terrestrial and freshwater taxa and 186 marine taxa. Greater Melbourne is defined as the 14 200 sq. km reaching from Bacchus Marsh and Lerderderg State Park in the west to Toolangi in the north-east, all of Phillip Island in the south-east and Torquay in the south-west. Separate maps show reserves and places of interest for the terrestrial and marine sections. Well-known groups –

birds, mammals, reptiles and amphibians – are chosen comprehensively. By necessity, invertebrates have had to be restricted to the common, the spectacular or the unusual. The marine section is restricted to the littoral and shallow water.



Does it Work?

The tests of the book will be how comprehensive and useful is the species' coverage and does it enable quick and accurate identifications. Let us start with the birds as they are the most easily observed group; 180 species are included. Of these, the inclusion of the Red-browed Treecreeper and the Southern Emu-wren, while omitting recent influxes of Grey Currawongs and Little Corellas, came as a bit of a surprise for modern Melbourne. In my bit of Melbourne the changes in the backyard bird list over the last ten years demonstrate the enormous changes in vegetation cover and altered hydrology that comes from intensive population growth. It would now be a great challenge to try and see all 180 species within a year in the area covered by the map on page xii. This book would be field guide enough as the photographs and descriptions are unambiguous. The notes are worth a browse to pick up interesting bits of information such as Great Crested Grebes eating their feathers to aid digestion, but to describe the call of the Little Wattlebird as 'mellow' is stretching it a bit; to me it is a raucous 'cooked apples'.

Two monotremes, twenty marsupials, seventeen bats and thirteen other placentals (nine of which are introduced) are the mammal complement. For most of them where they may be found in Greater Melbourne is listed and we are warned of two additional *Antechinus* that might be encountered. In the absence of any caution about catching or handling, do we need to examine them in the hand for identification? For the bats, yes; for the rest, mostly no. The Sugar Glider usually has a white tip to its tail, beautifully shown in the photograph on p. 227 and, from other sources, we read that this is a good field character to distinguish it from the Squirrel Glider, not a Greater Melbourne resident. I have stared long and hard at the book's front cover wondering whether that tail tip is tending towards white, but it is a Squirrel Glider.

When we realise the number of freshwater fish (30), frogs (15), freshwater turtles (3), lizards (28) and snakes (9) listed for the Melbourne area we are surely surprised. Each native fish family has an introduction, which includes a fin formula or description that distinguishes it, and individual descriptions separate the species. Nine species accidentally or deliberately introduced into Victorian waters are included. In the absence of any specimens I used pictures from another field guide as a surrogate and was able to identify species. As their names suggest, *Crinia signifera* and *C. parinsignifera* are two very similar frogs which require experience to separate. Field marks, combined with the photographs, should be adequate to give you a high degree of success with the others, but read the descriptions carefully, being alert for the comment 'usually present'. *Litoria ewingi* and *L. verreauxii* might prove tricky. Because they are so hard to translate into English, a website address is given where frog calls may be heard.

There are sixteen species of small brown skinks with subtle differences in their

stripes, colours and types of scale. You won't identify them if you just get a fleeting glance, and even a photograph would need to be carefully oriented; you really need a specimen in the hand and in some cases some magnification to check the scales. The best technique will be to eliminate the obviously wrong species; the photographs are a great help with that. Then a slow and cautious stripe by stripe comparison should get you there. Nomenclature is up to date and the results of recent genetic work are given. All of the venomous snakes carry a warning (in the book) but the descriptions include scale counts and other features which need close examination; OK for road kills or sloughed skins but a bit dangerous otherwise. Again, very careful observation and reference to the descriptions and photographs are needed but juveniles will cause confusion.

When asked about the nature of God, biologist and atheist JBS Haldane replied that 'if He exists, He has an inordinate fondness for beetles'. One-third of Australia's named insect species are beetles, but this ratio is not replicated in the guide. Butterflies are overly represented and yet they have their own field guide. This brings us to the insects and other invertebrates. Freshwater insects have a section of their own and it is here I have found the first serious error in the book. *Notoaeschna sagittata* is a very poor choice for a Greater Melbourne dragonfly, being found in the north-east of the State, and the photograph of the adult is really a *Diplacodes*, which is common throughout suburban Melbourne.

Within the terrestrial insects there are the big groups (flies, bugs, beetles, wasps and moths) and the lesser known (lacewings, termites, web-spinners scorpion-flies, thrips and booklice). With so many to choose from, selection of species to include would not have been easy. The selectors have done a good job but I would willingly trade a few of the rarer butterflies for some more beetles. It would have been useful for family names to be included, particularly in what I have called the big groups, so that relationships might be more easily seen. Identification of insects, even to just family, is rarely easy, especially from photographs. Nevertheless, for most of the species in the guide you should have a fairly high degree of success at least to the 'almost like' identification level. But look at the photograph of the ked on p. 84 and tell me how it differs from *Tapeigaster*, the fly which establishes a territory on toadstools where the females lay their eggs.

Information about terrestrial invertebrates other than insects is even harder to find, so it is good to have a few worms, molluscs, crustaceans, spiders and scorpions. Typical species have been chosen and, with usual caveats of the need for careful observation and the fact that there can be hundreds of others within the same group, identification from the photographs and descriptions should be successful.

And finally, to the most pleasant discovery of all, a section on the marine and littoral species of near Melbourne beaches, groups whose information is spread widely and in obscure places. Like their terrestrial counterparts some species will be unequivocally identified from their photographs, some will need very careful scrutiny, and some will be 'possibly similar to' because of the great diversity. Over one hundred invertebrate descriptions cover the range nicely and complement those species mapped in the Coastal Invertebrates of Victoria Atlas. Fifty-seven fish and three mammals complete the survey.

Who Should Buy?

If you are visiting the area, are weight-restricted, but want to know what you are seeing, try to squeeze a copy into your day luggage. If you are starting to notice nature while there is still some left, or are asked awkward questions by children but have only a small book collection, this could be the ideal starter pack. If your library is stocked with well thumbed copies of Pizzey, Simpson, Menkhorst, Cogger and even, perhaps, Zborowski, what then? In the contemporary scheme of things it is not an expensive book, it's nice to have it all in one place, and you will learn something new from the notes and the taxa you have glossed over up until now.

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